AUXILIARY AND SUPPLEMENTAL MINE RESCUE EQUIPMENT

BY W. DAN WALKER, JR., G. W. CHASTAIN, AND D. D. DORNENBURG

* * * * * * * * * * Information Circular 7808

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W. Dan Walker, Jr.,[1] G. W. Chastain,[2] and D. D. Dornenburg[3]

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SUMMARY AND INTRODUCTION

In recent years the Federal Bureau of Mines tested and approved four new types of self-contained breathing apparatus and a facepiece designed for use with the McCaa 2-hour self-contained oxygen breathing apparatus. The Bureau also developed and perfected a battery-powered lifeline telephone for use in mine rescue and recovery operations. Some of this equipment is described in Bureau of Mines Information Circular 7413.[4/] This publication is a revision of Information Circular 7413 and presents pertinent information on more recently developed mine rescue equipment.

The breathing apparatus described herein are 1/2- and 3/4-hour self-contained types of much simpler design than the conventional 2-hour self-contained oxygen breathing apparatus ordinarily used by mine rescue crews; however, it is just as important to select rescue crews carefully and to train them properly in the use, care, and limitations of the newer types of apparatus as well as the older, established types, if the newer types are to be used safely. The Bureau of Mines recommends that 1/2- and 3/4-hour self-contained breathing apparatus be used only as auxiliary equipment in mine rescue and recovery work and that the capabilities and limitations of the apparatus should be well understood by those who wear the equipment.

Self-contained breathing apparatus can be used with reasonable safety while performing work under extremely hazardous conditions, provided the wearer is physically fit and expertly trained in procedures following fires and explosions and in the care, use, and limitations of the apparatus.

It is highly important that persons who expect to wear breathing apparatus in irrespirable atmospheres be properly instructed and properly trained in the construction, testing, use, and care of such apparatus. Moreover, apparatus men, after receiving thorough initial training, should receive additional training at least every 6 months to retain the instructions regarding the use and limitations of the apparatus. Many persons have encountered difficulties, with serious and even fatal results, while wearing self-contained breathing apparatus; in almost every instance the difficulties could be attributed to the poor physical condition of the wearer, poorly assembled or otherwise defective apparatus, lack of or improper training, or improper procedure. Therefore, the necessity of enough specialized instruction and training in the use and care of breathing apparatus of all types, including the types of apparatus described in this circular, cannot be emphasized too strongly.

As 1/2- and 3/4-hour apparatus are approved only as auxiliary mine rescue apparatus, the 2-hour conventional-type, self-contained apparatus must be used as the basis for the training; however, some time should be devoted to other types of breathing apparatus, and special emphasis may be placed upon any certain type of

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4/ Grove, G. W., and Quenon, E. E., Approval of Newly Developed Self-Contained Breathing Apparatus. Instructions in Its Care and Use, and Training Procedure: Bureau of Mines Inf. Circ. 7413, 1947, 18 pp.

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breathing apparatus during the training. Part of the time required to be spent in wearing the 2-hour-type apparatus should be applied to other types of breathing apparatus if such apparatus are available.

The types of breathing apparatus described in this publication, being approved only as auxiliary apparatus, should not be used in mine rescue work, except very close to fresh air, unless at least 1 team of 5 or 6 men equipped with self-contained breathing apparatus is in reserve at the fresh-air base.

Persons directing rescue and recovery operations following mine explosions and fires should, without exception, follow the best-known and established safety practices in the protection of those who are engaged in such work, and it should always be stressed that no type of breathing apparatus is foolproof either in its construction or in its use in an irrespirable atmosphere.

Relatively new equipment - the Chemox apparatus facepiece, modified to permit its use with the McCaa 2-hour apparatus, and a battery-powered lifeline telephone, which can be used safely in explosive mixtures of methane and air - appears to fill the need for more efficient and reliable apparatus and a means of communication between the mine rescue team and the fresh-air base.

ACKNOWLEDGMENT

The writers wish to acknowledge the advice and assistance of George L. Freas, A. E. Morrow, and W. M. Demkowicz, of the Bureau of Mines, in preparing this publication. This opportunity is taken to express appreciation for the work of George Freas and Kenneth Lipman in designing the transistor telephone described herein. Freas also rendered valuable service in testing and making necessary adjustments of the Chemox facepiece to make it suitable for use with the McCaa 2-hour breathing apparatus. Many other Bureau of Mines writers have contributed in one way or another to the material presented, and to each we wish to express our sincere appreciation.

CHEMOX OXYGEN BREATHING APPARATUS

Origin and Approval

During World War II a self-contained oxygen breathing apparatus in which oxygen was supplied by chemical reaction was used extensively by the United States Navy in fire-fighting operations. After the war this apparatus, known as the Chemox, was made available for industrial use. The oxygen supply in the Chemox apparatus is generated in a canister containing potassium superoxide (KO_2). Moisture in the exhaled breath of the wearer causes the potassium superoxide to liberate oxygen as follows: $4KO_2+2H_2O=4KOH+3O_2$, and the exhaled carbon dioxide is retained in accordance with the following equation: $2KOH+CO_2=K_2CO_3+H_2O$. The rate of oxygen liberation is governed by the rate of breathing of the wearer. The canister will supply oxygen for a minimum of 45 minutes to a wearer performing arduous labor.

The Chemox apparatus, manufactured by the Mine Safety Appliances Co., Pittsburgh, Pa., was submitted to the Bureau of Mines for testing in accordance with Schedule 13C[5/] and was formally approved October 3, 1946; approval No. 1307 was issued to the manufacturer. Extension of approval No. 1307 was granted December 10, 1948, to

5/ Bureau of Mines, Procedure for Testing Self-Contained Breathing Apparatus for Permissibility: Schedule 13C, July 9, 1946, 11 pp.; revised and reissued as Schedule 13D, Sept. 22, 1956, 12 pp.

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permit the use of a facepiece equipped with a speaking diaphragm; and extension of approval was granted May 19, 1949, to permit the use of a sound-powered lifeline telephone transmitter. Figure 1 shows details of the Chemox oxygen breathing apparatus.

The apparatus was approved with the following provisions:

1. That it be known and used as a 3/4-hour self-contained oxygen-generating breathing apparatus.

2. That the facepiece be stamped or marked with Bureau of Mines approval No. 1307.

3. That an approval plate bearing specified statements relative to limitations of use be securely attached to the front of the canister holder. (Fig. 2 shows the approval plate.)

Parts of Apparatus

The Chemox oxygen breathing apparatus, complete with canister, weighs about 13-1/2 pounds and consists of the following principal parts:

1. Facepiece assembly.
2. Plunger assembly.
3. Canister.
4. Breathing bag.
5. Timer.
6. Breastplate and frame.
7. Harness assembly.

Facepiece Assembly

The facepiece assembly consists of a facepiece; a head harness; a metal valve housing containing an inhalation check valve, an exhalation check valve, and a pressure-release valve assembly containing a fixed check valve to prevent entrance of outside air; a speaking diaphragm; and two breathing tubes. The facepiece originally approved was not equipped with a speaking diaphragm; however, all facepieces being manufactured at present are so equipped.

The All Vision facepiece used with the Chemox apparatus is molded rubber with ducts entering immediately below the shatterproof contour lenses. The dry oxygen from the breathing bag enters the facepiece through the ducts and flows across the inner surfaces of the lenses to prevent fogging.

Attached to the lower part of the facepiece is a metal cylindrical housing containing 2 removable check valves and 1 fixed, mica-disk check valve. The two removable check valves are the inhalation and exhalation valves, both of which are mica-disk valves. The inhalation and exhalation valves are used to insure a positive flow of air in one direction so the wearer cannot rebreathe exhaled air until it has been purified and replenished with oxygen. The inhalation and exhalation check valves are activated by inhalation or exhalation pressure.

The pressure-release valve, which is mounted on the front of the housing, is a rubber-disk valve that is opened by pressing a plunger connected to it and is kept in the closed position by a coil spring, except when manually opened. It permits the wearer to release excess pressure that builds up in the breathing bag.

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Figure 1. - Chemox apparatus layout.

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PERMISSIBLE
THREE-QUARTER HOUR
SELF-CONTAINED OXYGEN-GENERATING
BREATHING APPARATUS

APPROVAL **NO. 1307**

Issued for safety, practicability, and
efficiency in general service to the

MINE SAFETY APPLIANCES COMPANY
PITTSBURGH, PENNSYLVANIA, U. S. A.

CAUTION

1. Approved only for respiratory protection in oxygen-deficient atmospheres, or in vapors or gases which do not poison by skin absorption. (Hydrocyanic acid gas is absorbed through the skin.)
2. Not approved for successive wearing periods or prolonged use in highly concentrated petroleum vapors.
3. Approved only when assembled with Bureau of Mines approval No. 1307 canister and Bureau of Mines approval No. 1307 facepiece.
4. The cautions and instructions printed on the oxygen-generating canister must be fully complied with.

Figure 2. - Chemox approval plate (No. 1307).

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The check valve used in conjunction with the pressure-release valve is a fixed or permanent mica-disk valve, through which air can travel in one direction only (to the outside atmosphere). The mica disk is held in place on the valve seat by a coil spring in a spider that is pressed when manufactured into holes drilled in the outer edge of the valve seat. This valve prevents the outside atmosphere from entering the breathing apparatus when the pressure-release valve is open.

The facepiece, with a speaking diaphragm approved for use with Chemox apparatus, is identical to the facepiece described, except for the addition of the diaphragm. The speaking diaphragm is provided to facilitate communication from persons wearing the apparatus. It is attached to the front of the facepiece immediately below the lenses and consists of a metal housing, a perforated-metal disk, a rubber gasket, a flexible plastic-disk diaphragm, a rigid plastic spacer ring, a metal front guard, and a metal retainer ring.

The rubber gasket is slotted to fit over the rim of the perforated-metal disk so as to provide a sealing gasket between the inner side of the disk and the diaphragm housing and between the outer side of the disk and the flexible plastic diaphragm. The spacer ring exerts pressure on the parts contacting the rubber gasket, insuring an airtight seal when the retainer ring, which screws onto the housing, is tightened. The front guard protects the plastic diaphragm against damage from an external source.

A transmitter of a sound- or battery-powered lifeline telephone can be attached to the speaking-diaphragm housing by removing the front guard and spacer ring and replacing them with the transmitter and a special spacer ring.

The two breathing tubes are attached to the ends of the valve housing cylinder by clamp-type metal straps. The inhalation tube enters the left side of the breathing bag by means of an elbow coupling. The exhalation tube couples to the plunger housing. The tubes are made of rubber to provide flexibility and are corrugated to add strength and prevent collapse.

The head harness used to hold the facepiece in position has five rubber straps radiating from a rubber centerpiece that rests on the top of the head of the wearer; the end of each strap is marked with its position in relation to the head of the wearer. The buckles for the straps are attached to the facepiece.

Plunger Assembly

The plunger assembly has four functions: It breaks the seal of the canister, seals the canister against the plunger housing, conducts exhaled air into the canister, and conducts dry oxygen into the right side of the breathing bag. These functions are accomplished by means of a spring-loaded stainless-steel plunger within a hollow metal housing mounted on the canister holder.

The plunger is a cylindrical tube with a perforated cone-shaped tip, which pierces the copper-foil seal in the neck of the canister when the canister is inserted in the canister holder. After piercing the copper foil, the plunger seats itself on the top of the vertical tube of the canister and thus permits the exhaled breath to enter it.

The bottom of the hollow housing is machined to insure sealing when the rubber gasket on the top of the neck of the canister is pressed against it. The housing also permits the evolved oxygen to pass between the inside of the housing and the plunger and into the right side of the breathing bag.

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Canister

The canister consists of a copper-plated steel shell and a copper inner lining. Immediately below the top of the canister is an airspace that permits evolved oxygen to pass. This airspace is maintained by formed wire bearing against the top of the canister and a shredded fiberglass padding held between two copper screens. Next is a layer of uncatalyzed potassium superoxide, separated by two copper screens from a bottom layer of catalyzed potassium superoxide. The bottom chemical is held in position by a fiberglass web cloth between 2 copper screens, which are held against the chemical by 3 wire springs bearing against the bottom of the canister. The action of these springs also provides an airspace in the bottom of the canister so that the moisture in the exhaled breath of the wearer will act on the total area of the chemical.

A copper-plated steel tube, through which exhaled breath passes, extends from the neck of the canister through the 3 sections of metal screens and the 2 layers of chemical into the airspace at the bottom of the canister.

The fiberglass pad and cloth are placed at the top and bottom of the chemical to act as filters and prevent dust particles, which might be formed in storage or rough handling, from entering the circulatory system. The canister is hermetically sealed to prevent air from coming in contact with the chemical. The copper-foil seal on the canister neck is protected in storage by a metal tear-off cap and metal and cardboard disks.

Breathing Bag

The breathing bag serves as a flexible lung, providing a reservoir and cooler for the generated oxygen. It is constructed in the shape of an inverted U and vulcanized at the seams, and is highly resistant to fumes and gases. The bag has a capacity of approximately 6 liters (5-1/2 quarts).

Oxygen from the canister flows into the right side of the bag and is conducted by a flexible tube to within approximately 2 inches of the bottom of the bag. The left side of the bag has a tube in a similar position. The oxygen enters this tube when the wearer inhales. This flow path causes the oxygen to circulate across the entire area of the bag, cooling it before it reaches the facepiece. (See fig. 3.) The bag is held to the breastplate by tabs and screws.

Timer

The timer is entirely mechanical and operates independently of the breathing circuit. It is mounted on the plunger housing, and the dial is visible at all times to the wearer.

The function of the timer is to indicate the time the canister has been in service. The dial is calibrated in minutes and provides settings up to 45 minutes.

The timer is actuated by turning the pointer clockwise to the number on the dial that corresponds to the number of minutes in the interval to be timed. The turning automatically winds the timer, and the continuous movement of the pointer to zero unwinds it. When the pointer reaches the zero setting, it rings a bell, so the wearer receives an audible warning if he should fail to note visually the end of the timed interval.

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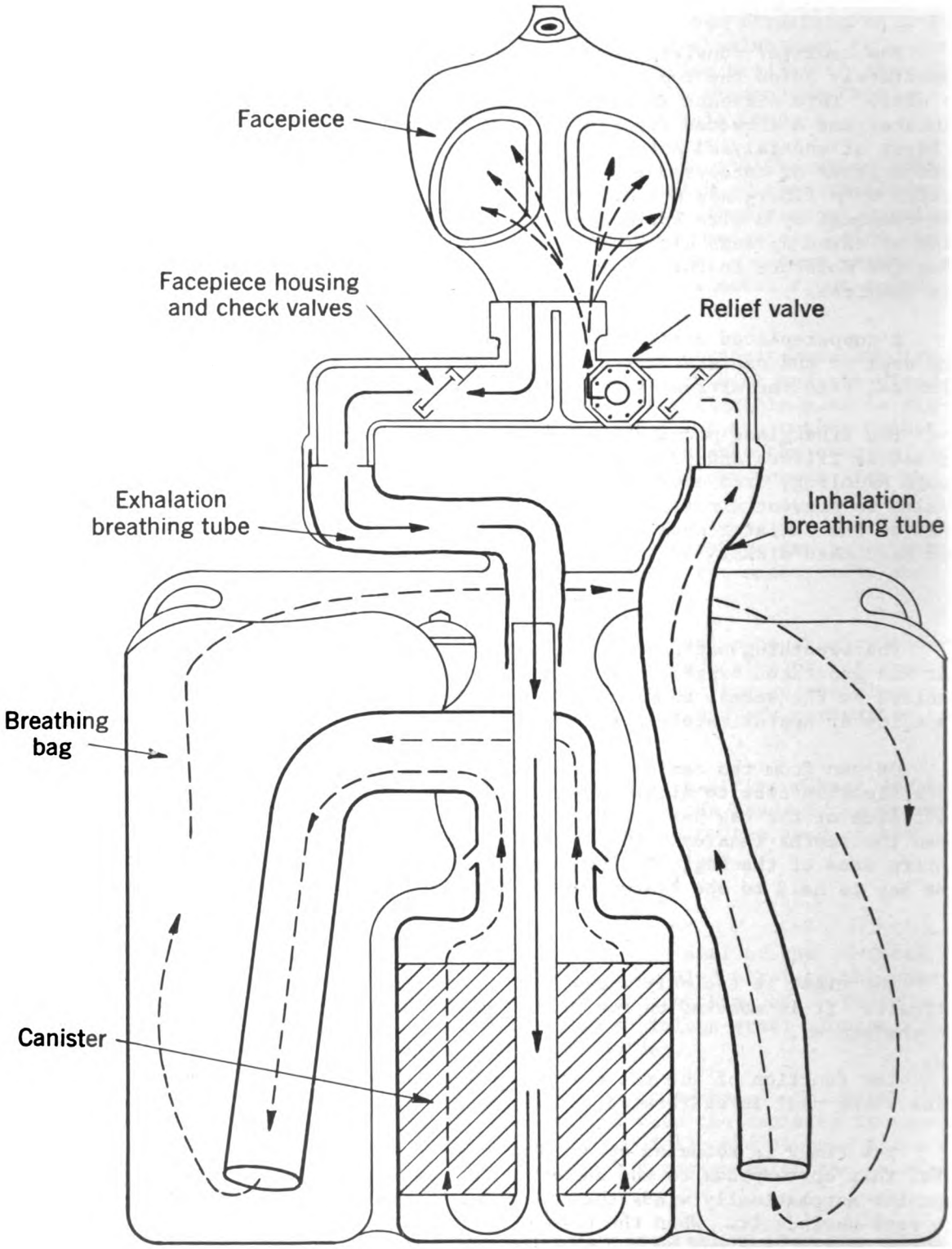

Figure 3. - Flow diagram of Chemox.

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Breastplate and Frame

The breastplate and frame assembly consists of an insulated breastplate, an insulated canister holder, and a bail with a handwheel attached to a thread bar.

The breastplate and canister holder are covered with insulating material to protect the wearer from the heat generated by the chemical reaction in the canister. The bail is attached to the canister holder so it can be swung outward and upward to facilitate placing and removing the canister. The handwheel is attached to the lower end of a thread bar that passes through a hole in the bottom of the bail; a metal plate is attached to the upper end of the thread bar. The handwheel is provided so that the thread bar can be turned and cause the plate to exert pressure on the bottom of the canister, thereby holding it in place and maintaining pressure of the canister against the plunger housing to keep the joint sealed.

The frame is made of sheet steel, but the design requires little metal, so the weight is kept at a minimum.

Harness Assembly

The harness consists of straps of strong black cotton webbing. It can be attached quickly to the apparatus by snaps, which fasten into D-rings fastened to the top of the apparatus frame. A waist strap is also provided to prevent outward movement of the apparatus, such as might occur when the wearer is bending over. The harness and waist straps can be adjusted to fit the wearer by means of slides. The waist strap snaps into holes in the bottom of the apparatus frame. A D-ring, to which a lifeline may be attached, is provided on the harness.

Circulatory System

When the wearer of the Chemox apparatus exhales, the inhalation valve seats itself and the breath is forced through the exhalation valve and tube, the plunger, and the tube of the canister to the airspace at the bottom of the canister. (See fig. 3.) The breath then expands, passing upward through the fiberglass-web cloth and copper screens into the catalyzed potassium superoxide. Here the moisture of the breath activates the chemical and liberates oxygen and an agent to retain carbon dioxide.

The liberated oxygen rises through the remaining chemical and fiberglass pad into the plunger housing and into the tube that extends to within approximately 2 inches of the bottom of the right side of the breathing bag. The temperature of the oxygen is reduced by exposure to the sides of the breathing bag. The oxygen, after filling the right side, passes across the top of the breathing bag into the left side, where it is drawn to the bottom and into the tube that is connected to the facepiece inhalation tube. When the wearer inhales, the oxygen passes through the inhalation tube, inhalation valve, and the facepiece built-in ducts and to the lungs of the wearer.

Preparing Apparatus for Use

Inspection

The apparatus should be inspected and tested periodically when it is not being used and should be inspected and tested carefully for working condition and airtightness immediately before being worn in irrespirable or poisonous gases. Defective parts should be repaired or replaced, and leaks should be eliminated before the

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apparatus is used. The following inspections and tests will show whether the Chemox apparatus is ready for use:

Inspect the facepiece for deterioration, particularly around the lenses, diaphragm, and valve assembly; see that the lenses are firmly attached and are not cracked or broken; check the head harness for deterioration and broken straps or buckles; and examine the breathing tubes for deterioration and to determine that they are securely attached to the valve-assembly cylinder and coupling nuts and that a gasket washer is in each coupling nut. The inhalation and exhalation check valves should be examined periodically for corrosion. The valves are removed by loosening the hose clamps that hold the breathing tubes on the valve cylinder, removing the breathing tubes, then sliding the valves out. The inhalation and exhalation valves are stamped with the letters IN and EX, respectively, and the cylinder is stamped near each end in a like manner to indicate the proper location of each valve; however, the valves cannot be misplaced in the cylinder because the housing of each is different in construction.

Examine the breathing bag for deterioration, separation at the seams, and tears or holes and to ascertain that the tubes are in the proper position inside the bag. The couplings to the plunger housing and the screws that hold the bag on the frame should be tight.

Inspect the plunger housing for holes or cracks and the plunger for cleanness and freedom of movement; the plunger tip should be free of foreign matter and not be deformed.

The timer should be firmly attached to the plunger housing with the timer-setting knob in place. The timer scale should be legible.

The breastplate and frame assembly should be inspected to see that the insulation is in good condition and completely covers the breastplate, that the bail is properly attached to the frame and the handwheel moves freely, and that the harness straps are not deteriorated and the snaps, D-rings, and adjusting slides are in working condition and properly attached.

Canisters should be examined before they are used to see that the tear-off cap is in place, the seams are tight and not deformed, and the canister is free of cracks, punctures, or any kind of opening.

Donning and Testing

The apparatus must always be donned in fresh air. The following are the consecutive steps in donning the apparatus before entering a toxic atmosphere:

Unfasten and straighten all harness straps.

With one hand, grasp the apparatus by the plunger casting, dropping the facepiece over the hand holding the apparatus. With the other hand, grasp the D-ring assembly where the 2 large web straps are joined, place the breastplate on the chest, and slip the head through the V-shaped opening formed by the 2 web straps.

Continue to hold the apparatus on the chest with one hand and with the other reach around the body and grasp the free end of the web strap on that side. Bring the end of the strap under the arm and snap into the D-ring on the top side of the breastplate. Repeat this procedure with the other strap.

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Adjust the position of the apparatus on the body by means of the metal slides on the web harness straps. The position of the apparatus on the body should be such that when the facepiece is put on the breathing tubes will permit free movement of the head.

Attach the waist strap to the small openings in the lower part of the frame, pull up to a snug fit, and tuck in the loose ends.

Remove the metal tear-off cap of the canister by pulling the metal tab straight out and straight back across the top of the cap, then remove the metal and cardboard disks and expose the copper-foil seal. With the handwheel screwed down far enough for the bail to be swung outward, swing the bail outward and insert the canister fully into the canister holder. The smooth side of the canister must be to the front. The canister should be inserted far enough that the copper-foil seal is punctured and the rubber gasket fits snugly against the V-shaped recess in the plunger casting. Screw the handwheel clockwise until it is tight against the canister.

After applying fogproof solution to each side of the facepiece lenses, pull out the facepiece headband straps so that the ends are at the buckles and grip the facepiece between thumbs and fingers. Insert the chin well into the lower part of the facepiece and pull the headband straps back over the head. To obtain a firm and comfortable fit against the facepiece at all points, adjust the headband straps as follows:

See that straps lie flat against head.
Tighten lower (neck) straps.
Tighten side straps. (Do not touch forehead, or front strap.)
Place both hands on headband pad and push in toward the neck.
Again tighten lower and side straps.
Tighten forehead (front) strap a few notches if necessary.

Check tightness of the facepiece fit by squeezing the breathing tubes and inhaling gently. The facepiece should collapse on the face if the seal is satisfactory. Figure 4 shows the Chemox apparatus as worn.

To start chemical reaction, squeeze both breathing tubes with one hand, break the seal of the facepiece against the cheek with finger and inhale, then release the breathing tubes and facepiece and exhale into the apparatus. Repeat this procedure until the breathing bag is fully inflated. Depress the pressure-release valve and force the air from the breathing bag with the forearms. Reinflate the breathing bag by repeating the starting procedure.

The Chemox apparatus should be stored and started at temperatures above 32° F. The wearer may then enter and wear the apparatus in temperatures down to 0° F. When starting the apparatus at temperatures near freezing, more inhalations from the outside air, with exhalation into the canister, may be required to produce the proper chemical reaction. The best procedure is to continue fully inflating and breathing bag and then deflating it with the forearms until a total of about 15 exhalations have been put through the canister.

To check the complete apparatus for tightness:

Grasp the lower end of the inhalation (left) breathing tube and squeeze it tightly. Inhale and if the facepiece collapses the facepiece seal is sufficiently tight and the exhalation valve is functioning properly. This test will also check the valve housing and upper part of the inhalation breathing tube for leaks.

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Figure 4. - Chemox apparatus as worn.

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Continue to squeeze the lower end of the inhalation breathing tube. Depress the pressure-release valve button, then inhale, and if the facepiece collapses as above the check valve used in conjunction with the release valve is functioning properly.

Release the inhalation tube and squeeze the lower end of the exhalation (right) breathing tube. Inhale and then exhale forcibly, and if the exhaled air is forced out between the face and the facepiece only, the inhalation valve is functioning properly and the upper end of the exhalation tube is free of leaks.

With the bag well inflated, grasp and close the upper ends of both breathing tubes and depress both sides of the breathing bag with the forearms. If the breathing bag does not deflate, the complete apparatus is tight.

If a leak or defect is indicated in any part of the apparatus, the condition should be located and corrected before the apparatus is used. Leaks may be found by applying soapy water to parts under pressure.

Breathe normally, as the apparatus furnishes enough oxygen to meet any breathing requirements.

Because the apparatus has a 3/4-hour service life at hard work in an irrespirable atmosphere, it will be necessary to determine the length of time required to return to fresh air from the working place and set the timer accordingly. The timer dial is calibrated in minutes, and by turning the pointer clockwise to the number of minutes left after deducting the time for exit, the timer will be properly set. For example, if 10 minutes will be required to return to fresh air, deduct 10 minutes from 45 and set the time at 35. The bell on the timer will ring when the pointer returns to 0, at which time the wearer must return to fresh air.

It is not necessary to purge nitrogen from this apparatus, as more oxygen is produced than is consumed; releasing excess pressure through the pressure-release valve simultaneously purges any nitrogen. When exhalation becomes difficult, release the excess pressure by depressing the plunger of the pressure-release valve on the valve housing at the bottom of the facepiece and partly deflate the breathing bag with a forearm.

There are two indications (in addition to the timer) that the canister is becoming expended - fogged lenses on inhalation and increased resistance of exhalation. These two indications will not normally appear until after 45 minutes of use but may under conditions of extreme hard work become noticeable. The lenses will clear on inhalation until the canister is almost expended; then they will begin to fog. Do not confuse excess breathing-bag pressure with canister resistance. If excess breathing-bag pressure is relieved by using the pressure-release valve and resistance to exhalation persists, the canister is about expended. If either indication appears, return to fresh air.

Maintanance and Care

Changing Canisters

Never allow any substance to enter the neck of the canister, especially oil, water and oil, gasoline, grease, etc., as the chemical in the canister contains oxygen, which will cause combustion of any inflammable materials brought into direct contact with it, especially if such materials are moist.

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To remove the canister, turn the handwheel down (counterclockwise), swing bail outward, and remove the canister with the hand, suitably protected by a glove or other covering, as the canister may be hot. Do not reuse the canister.

Always follow these instructions before discarding the canister: Remove canister to surface, punch a small hole in front, back, and bottom, and place in bucket of clean water far enough to cover it at least 3 inches. When bubbling stops, any residual oxygen will have been dissipated and the canister will be expended. Pour the residual water, which is caustic, down a drain or dispose in any other suitable manner and then discard the canister. Do not puncture canister underground, because friction from a metal-piercing tool or nail in conjunction with liberated oxygen and coal dust can cause an ignition.

Cleaning and Storing Apparatus

After each use the facepiece assembly should be disconnected from the apparatus and cleaned and disinfected; and the speaking diaphragm should be disassembled and the parts cleaned and dried separately.

Clean the assembly by washing it with soap and water and disinfect it by scrubbing with a cloth dampened (not sopping wet) with a 3-percent solution of carbolic acid, a 2-percent solution of lysol, or a solution of formaldehyde made with 1 part formalin (40-percent solution of formaldehyde) and 9 parts water. Then rinse the assembly with water and hang it up to dry.

When not being used, the apparatus should be kept in the carrying case provided, and canisters should be stored in a cool, dry place.

SCOTT AIR-PAK 1/2-HOUR BREATHING APPARATUS

Approval Requirements

The Scott Air-Pak self-contained, compressed-air, 1/2-hour breathing apparatus is manufactured by the Scott Aviation Corp., Lancaster, N. Y. The apparatus was submitted to the Bureau of Mines by the manufacturer for testing in accordance with the provisions of Schedule 13C[6/] and was formally approved October 3, 1946; approval No. 1308 was issued to the manufacturer. The apparatus was approved with the following provisions:

1. That the compressed-air cylinder be charged with not more than 1,980 pounds per square inch (1,800 pounds, plus 10 percent, as allowed by the Interstate Commerce Commission (ICC)).

2. That the main closing valve on the cylinder and the valve on the high-pressure tube at the regulator be provided with a suitable device for locking the valves open.

3. That the harness be so constructed that it can be adjusted to fit the wearer.

4. That the harness straps be padded where they contact the shoulders and that a pad be attached to the harness between the reducing valve and where the reducing valve rests against the body.

6/ Bureau of Mines, Procedure for Testing Self-Contained Breathing Apparatus for Permissibility: Schedule 13C, July 9, 1946, 11 pp.; revised and reissued as Schedule 13D, Sept. 22, 1956, 12 pp.

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5. That the main closing-valve and bypass-valve wheels be secured with a screw at the end of the stem.

6. That the facepiece be stamped with Bureau of Mines approval No. 1308.

7. That a replaceable filter screen be installed between the cylinder valve and pressure regulator, the screen to be 100-mesh with a wire diameter of 0.005 inch and held in place with a hexagon hole screw.

8. That a metal plate bearing specified statements relative to limitations of use of the apparatus be securely attached to the metal frame of the apparatus. (Fig. 5 shows a facsimile of the approval plate.)

9. That the regulator assembly be stamped with Bureau of Mines approval No. 1308.

Figure 6 shows the complete apparatus.

Parts of Apparatus

The Scott Air-Pak weighs about 30 pounds and has 4 main parts:

1. Facepiece assembly.
2. Regulator assembly.
3. Cylinder and valve assembly.
4. Cylinder-holding frame and harness assembly.

Facepiece Assembly

The facepiece assembly consists of a molded-rubber facepiece, an exhalation valve, an inhalation tube, and a rubber head harness.

The facepiece is the full-vision type with built-in ducts, which cause the air to flow from the inhalation tube across the inner surfaces of the two shatterproof contour lenses to prevent fogging.

Immediately below the formed nose section of the facepiece is the exhalation valve through which the exhaled breath is discharged to the outside atmosphere. The valve is so constructed that air can pass through it in one direction only. It also acts as a secondary safety valve to prevent excessive pressure from building up in the apparatus. The base or seat for the exhalation valve is a molded part of the facepiece, and the valve is a formed, flexible-rubber disk with a protrusion from the center of the inner side that extends through a hole in the valve seat and holds the valve in position. The valve and valve seat are protected by a metallic valve cap, which fits over them and is held in place by the shape of the valve seat.

Extension of approval No. 1308 was issued April 16, 1957, by the Bureau of Mines to the Scott Aviation Corp. to cover a new type of facepiece assembly for use with the Scott Air-Pak and to cover some minor changes in parts of the apparatus.

The new-type facepiece assembly, the Scottoramic, has essentially the same parts as the older model. The major improvements are in the facepiece seal against the face and in the lens. A contoured-to-fit-the-face inner seal in the facepiece is held against the face of the wearer by air pressure in the facepiece and provides double sealing protection. The facepiece is equipped with a single nonbreakable lens,

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PERMISSIBLE
ONE-HALF HOUR
SELF-CONTAINED COMPRESSED AIR
BREATHING APPARATUS

APPROVAL **NO. 1308**

Issued for safety, practicability, and efficiency in general service to the

SCOTT AVIATION CORPORATION
LANCASTER, NEW YORK, U. S. A.

CAUTION

1. Approved only for respiratory protection in oxygen-deficient atmospheres, or in vapors or gases which do not poison by skin absorption. (Hydrocyanic acid gas is absorbed through the skin.)
2. Approved only when the compressed air cylinder is charged with air furnished by the manufacturer of the apparatus or by a reliable producer of compressed gases, and when the compressed air does not contain less than 20.50 percent oxygen and not more than 0.005 percent carbon monoxide.
3. Approved only for use with Bureau of Mines approval No. 1308 facepiece and Bureau of Mines approval No. 1308 pressure regulator and assembly.
4. Approved only when the compressed air cylinder is plainly marked, "To be filled with compressed air only."

Figure 5. - Scott Air-Pak approval plate (No. 1308).

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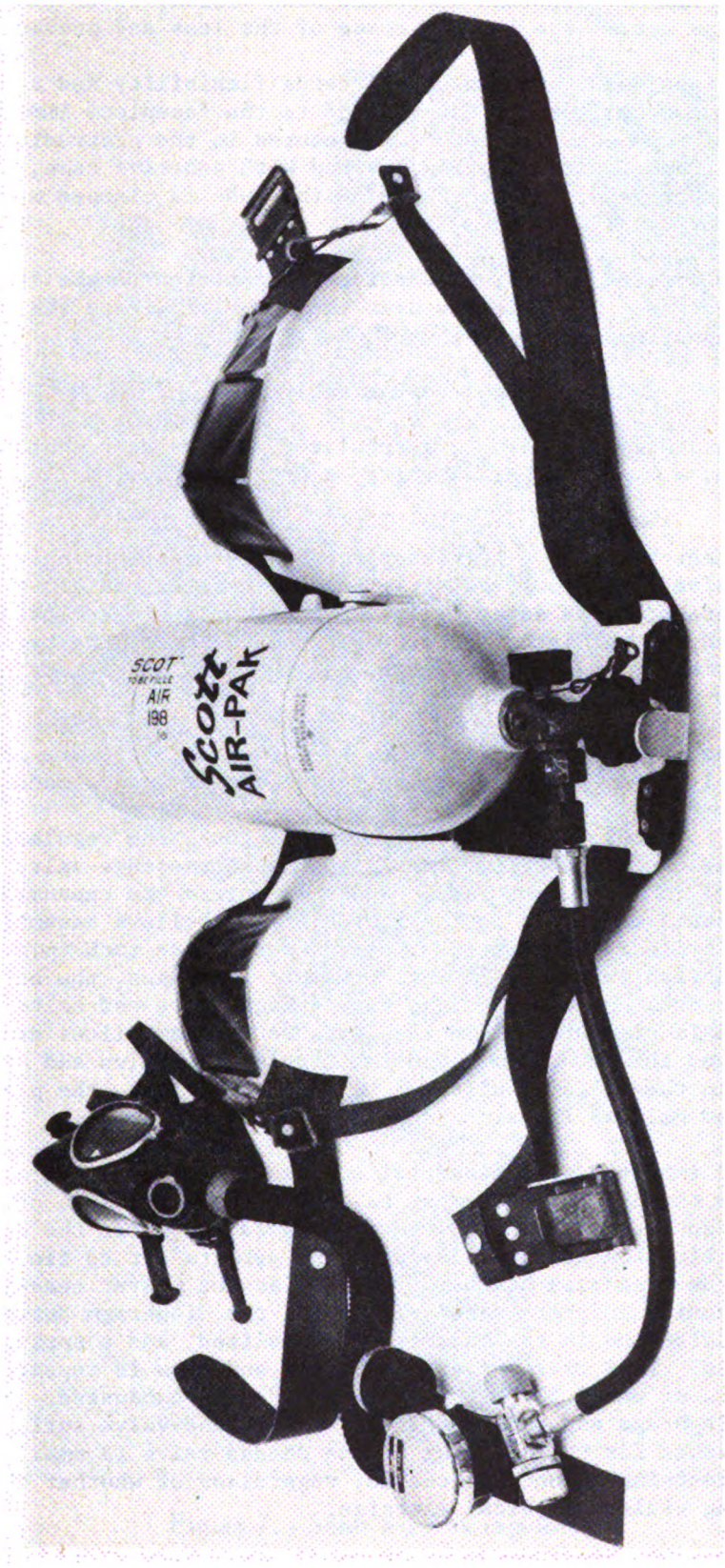

Figure 6. - Scott Air-Pak layout (with older type facepiece).

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which permits full forward vision and increased side vision; it is so designed that air entering it sweeps across the inner surface of the lens and prevents fogging.

The inhalation tube, made of rubber to provide flexibility and corrugated to add strength and prevent collapsing, is attached to the facepiece immediately below the exhalation valve. One end of the tube is secured in the protruding inlet of the facepiece with cement and a wire wrapping covered with adhesive tape, which in turn is covered with a rubber band; the other end of the tube is clamped with a metallic strap to the regulator coupling.

The rubber head harness holds the facepiece in position on the face of the wearer. It has six straps, each stamped near the end to indicate its proper position in relation to the facepiece and the head of the wearer.

Regulator Assembly

The regulator assembly consists of a regulator, a regulator shutoff valve, a valve-locking device, a bypass tube and valve, a pressure gage, and a regulator hose.

The essential features of the regulator are a pressure-reducing valve, an admission or demand valve, a bellows, an air-expansion chamber, an air-expansion passage, a rubber diaphragm, and a safety valve. These parts are enclosed in a housing to which are attached the regulator shutoff valve and locknut, the bypass tube and valve, the regulator hose, the pressure gage, and the inhalation-tube connection. Figures 7 and 8 show details of the regulator.

The primary function of the regulator is to reduce the pressure of the compressed air and supply it at normal pressure to the wearer upon demand.

Air at cylinder pressure enters the regulator through the regulator shutoff-valve orifice, passes through a filter screen to the first-stage-valve orifice, where it is throttled to a lower pressure, and then enters the expansion passage. From the expansion passage it goes to the inside of the bellows assembly, which is spring-loaded to maintain a pressure of 35 pounds per square inch (p.s.i.) in the bellows and the expansion passage. If this pressure increases, the bellows expands and actuates a lever arm, which closes the first-stage valve and halts the flow of air and the increase in pressure. When the pressure in the bellows decreases, the bellows contracts, and the lever arm opens the first-stage valve and holds it open until the pressure in the bellows builds up to 35 p.s.i. Thus, the pressure in the expansion passage and bellows is maintained at a constant 35 p.s.i.

When the wearer inhales, a differential in pressure between the outside atmosphere and the air in the expansion chamber is created; the pressure of the outside air, being greater, forces the rubber diaphragm inward and moves the demand-valve stem, which in turn tips the demand-valve disk and permits air to flow from the expansion passage to the expansion chamber. As soon as the wearer ceases to inhale, pressure in the expansion chamber increases, moving the diaphragm outward until the pressures on the outside and in the chamber are equalized, and a spring forces the demand valve to close. This cycle of air reduction and flow is repeated as long as the apparatus is worn or until the air in the cylinder is exhausted. Because of the large area of the diaphragm and the low rate of the demand-valve spring, the required negative pressure for full opening of the demand valve is small, and variation in effort of breathing is not noticeable, regardless of whether the wearer is at rest or performing violent physical exercise.

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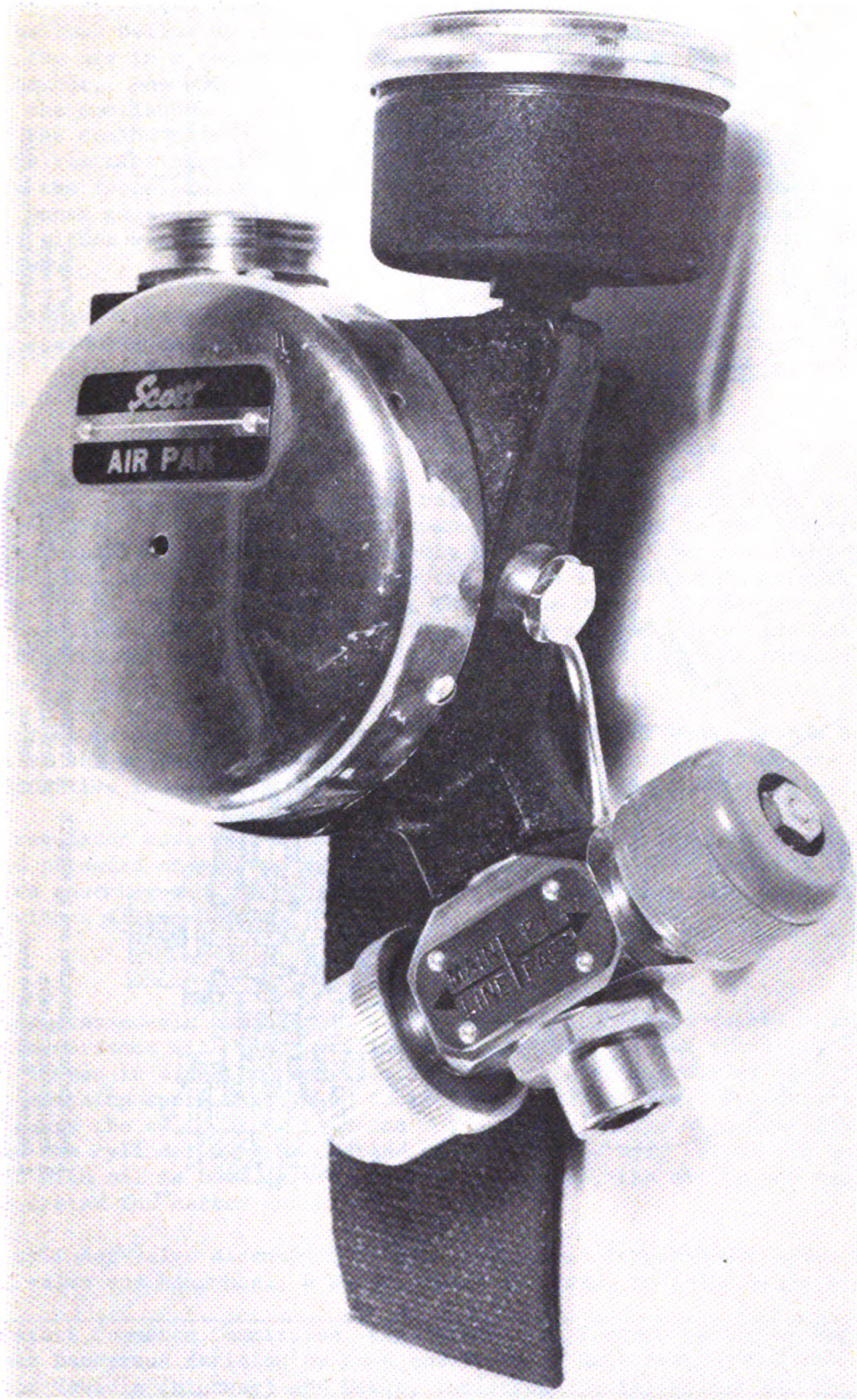

Figure 7. - Scott Air-Pak regulator.

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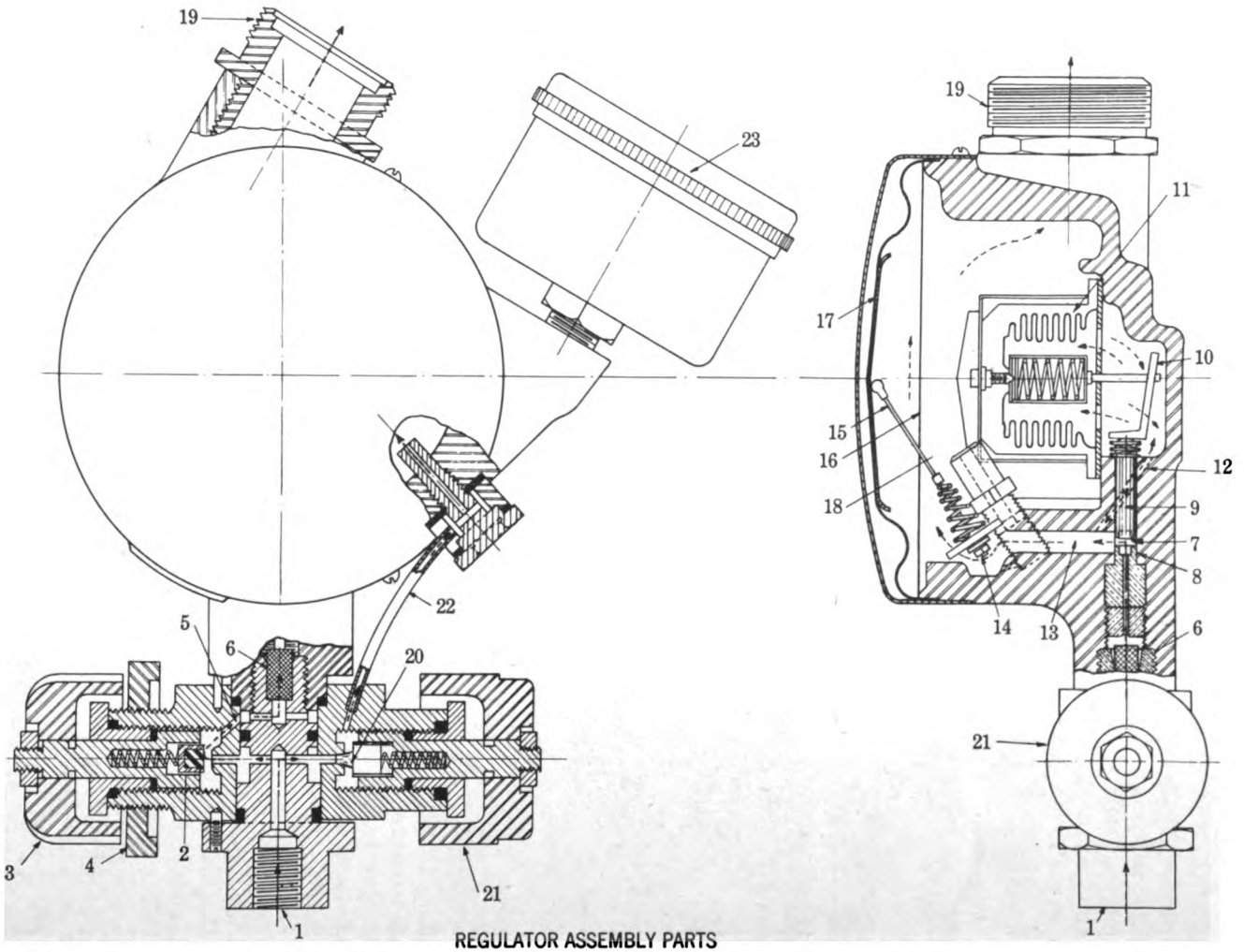

REGULATOR ASSEMBLY PARTS

1. Regulator hose connection and air entrance.
2. Regulator shutoff valve.
3. Regulator shutoff-valve knob.
4. Regulator shutoff-valve locknut.
5. Air passage from valve to filter screen.
6. Filter screen.
7. Nylon valve seat.
8. First-stage reduction valve and orifice.
9. First-stage reduction-valve seat plunger.
10. First-stage reduction-valve actuating lever.
11. Bellows.
12. Air duct between expansion passage and bellows.
13. Air-expansion passage.
14. Demand or second-stage reduction valve.
15. Demand valve stem.
16. Expansion chamber.
17. Diaphragm.
18. Safety valve.
19. Inhalation-tube connection.
20. Bypass valve.
21. Bypass-valve knob.
22. Bypass-valve tube.
23. Pressure gage.

Figure 8. - Diagram of Scott Air-Pak regulator.

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If the first-stage valve should stick open and pressure in the expansion passage and bellows builds up to more than 50 p.s.i., the safety valve would open and discharge the air in a continuous flow at a reduced pressure directly into the expansion chamber. The wearer would be warned that the initial reduction stage had failed by the continuous flow of air to the facepiece at a slightly positive pressure. If the demand valve should stick in the open position, the flow of air through the restricting orifice would be limited, so there would only be a tendency to inflate the facepiece, the pressure in the facepiece being held to less than 3 inches of water gage (15.6 lb./sq.ft.)because of the operation of the exhalation valve. If either valve should stick open, the wearer should leave the danger area immediately.

The plunger-type regulator shutoff valve, which is attached to the regulator housing, provides a means of shutting off the flow of air if the regulator should be damaged or fail to function. The valve is provided with a locknut to prevent it from being closed accidentally.

The bypass valve is a needle-type valve provided to furnish the wearer with air if the regulator is damaged or fails to function, and it should be kept closed unless such use is necessary. When the bypass valve is open, air at cylinder pressure passes through the bypass tube to the expansion chamber and to the facepiece. If needed, the bypass valve should be slightly opened first, then the regulator shutoff valve closed and the flow of air through the bypass tube adjusted to suit the requirements of the wearer by manipulating the bypass valve. To aid in properly identifying the valves, the regulator shutoff valve is painted yellow and has palpable external flutes, and the bypass valve is painted red and has fine external serrations.

The pressure gage, which is attached to the regulator where it can be seen at all times by the wearer, indicates the air pressure in pounds per square inch and provides positive indication of the quantity of air in the compressed-air cylinder.

The regulator hose is a rubber-covered music-wire - reinforced flexible hose with fixed threaded ends. One end of this high-pressure hose connects to the cylinder-valve assembly and the other to the regulator assembly; the cylinder end is provided with a filter screen.

Cylinder and Valve Assembly

The compressed-air cylinder is constructed of high-grade carbon steel and tested in accordance with ICC specifications.7/ The cylinder is 19-1/4 inches long and 6-3/4 inches in diameter, and when fully charged to a pressure of 1,980 p.s.i. at 70° F. contains approximately 40 cubic feet of normal air. Provisions of approval require the cylinder to bear the words "To be filled with compressed air only," and the cylinder must be charged only with pure air. If an air compressor lubricated with oil is used as a breathing-air source, the air in the cylinder should be tested for carbon monoxide.

The cylinder-valve assembly consists of a T-type forged-brass valve housing, a shutoff valve and handwheel, a safety chain and snap, an inlet stem, a pressure

7/ Interstate Commerce Commission, Regulations for Transportation of Explosives and Other Dangerous Articles by Land and Water in Rail Freight Service and by Motor Vehicle (Highway) and Water, Including Specifications for Shipping Containers: May 1954, and Supp. No. 8, August 1956.

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gage, and a safety plug. The shutoff-valve stem is threaded into the valve housing, and a locknut and shoulder prevent it from being turned completely out of the housing. One end of the safety chain is attached to the cylinder pressure gage, and the other is provided with a snap, which is snapped on the handwheel when the apparatus is being worn to prevent accidental closing of the valve. The inlet stem is a copper tube, which extends from the base of the valve housing into the center of the compressed-air cylinder to prevent sediment or rust from entering other parts of the apparatus. The pressure gage, threaded into the valve housing, constantly indicates the pressure of the air in the cylinder in pounds per square inch. The safety plug, attached to the valve housing by a threaded connection, is provided to relieve excessive pressure, which might be caused by heat or other means. Figure 9 shows details of the cylinder-valve assembly.

Cylinder-Holding Frame and Harness Assembly

The cylinder-holding frame is tempered aluminum, 3/32 inch thick and 15-1/2 inches long, tapered in width from 7-1/2 inches at the bottom, as worn, to 9-1/2 inches at the top. A metal band, which holds the compressed-air cylinder in place when tightened by a cam lever, and a metal cylinder-valve guard are attached to the frame. The harness consists of 2 shoulder straps, which are padded where they cross the shoulders, 2 body straps, extending from the bottom of the cylinder-holding frame to the ends of the shoulder straps on the chest, 1 strap across the chest connected to the shoulder straps, and 1 waist strap. The shoulder and body straps are riveted to the cylinder-holding frame, and the waist strap is threaded through slots in the bottom of the frame. The harness straps are made of Neoprene-coated heavy cotton webbing and are equipped with adjustable buckles and snaps so that the harness can be adjusted to fit the wearer.

Flow of Air

Air in the Scott Air-Pak flows directly to the wearer without being recirculated or purified in the apparatus. It flows under pressure from the compressed-air cylinder through the regulator hose into the regulator, where it undergoes two stages of pressure reduction, and then flows through the inhalation tube and facepiece to the lungs of the wearer. When the wearer exhales, the airflow stops, and the exhaled breath passes through the exhalation valve to the outside atmosphere.

Testing and Wearing Apparatus

The apparatus should be tested periodically when it is not being used and should be inspected and tested carefully for airtightness and working condition immediately before being worn in irrespirable or poisonous gases. All leaks found during tests should be corrected and defective parts repaired or replaced before the apparatus is used. Only parts supplied by the manufacturer should be used as replacements. The following tests and inspections will show whether the Scott Air-Pak is ready for use.

Tests for Tightness of Cylinder Valve

Apply a soap-and-water solution to the valve-body connection to the cylinder, the cylinder-pressure gage and its connection to the valve body, and the safety plug. Expanding bubbles indicate leaks. Leaks at connections may be eliminated by tightening the connections; however, if leaks are caused by defective parts, such parts should be repaired or replaced.

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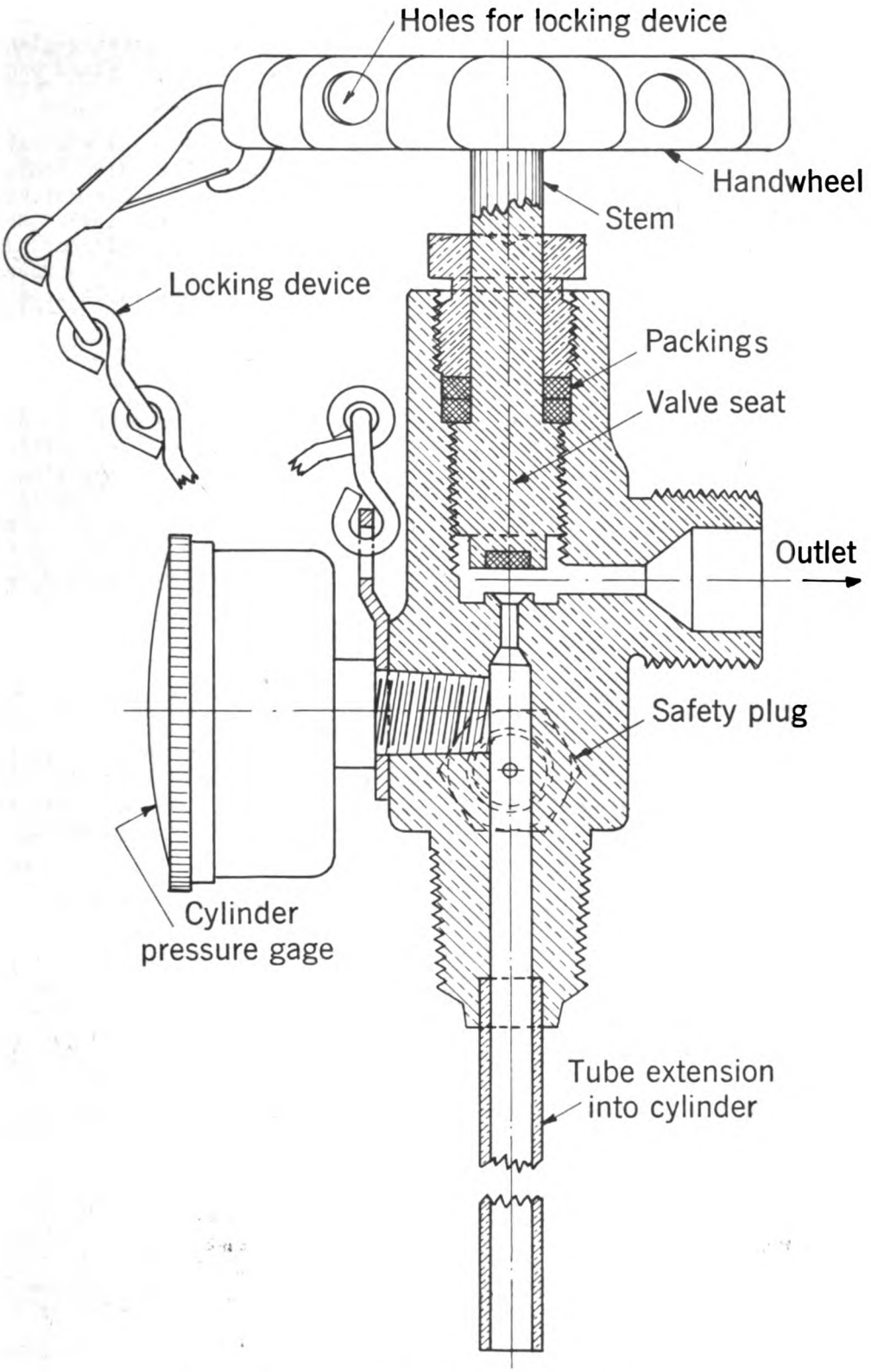

Figure 9. - Scott Air-Pak cylinder valve.

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With the regulator hose attached to the cylinder valve and regulator, and the cylinder valve open, apply soapy water around the valve stem and packing-gland nut. If bubbles appear, the packing-gland nut should be tightened or the gland packing replaced.

With the regulator hose disconnected from the cylinder valve and the valve closed, apply soapy water to the regulator-hose connection on the valve body; if bubbles form the valve seat is leaking. Opening and closing the valve quickly several times may blow foreign matter from the valve and eliminate the leak. However, if the leak continues, bleed all pressure from the compressed-air cylinder, and then disassemble the valve and repair or replace defective parts. The manufacturer recommends that Dow Corning silicone stopcock grease be applied to the valve-stem-gland packing when reassembling the valve.

Tests for Tightness of Regulator Hose

With the bypass valve closed and the regulator shutoff valve open, open and close the cylinder valve and observe the regulator pressure gage. Any deflection of the pressure-gage needle indicates a leak. Leaks can be located by applying soapy water to the regulator hose and connections and the quick-connect opening of the regulator. If a connection leaks, tightening the connection will eliminate the leak in most instances; if the connection is defective, it should be repaired or replaced. Blisters on the hose do not necessarily indicate that it is defective; the blisters should be deflated by pricking them with a pin.

Tests for Tightness of Regulator

When the regulator shutoff and bypass valves are closed and breath can be exhaled through the quick-connect opening into the regulator, the regulator or diaphragm leaks. To locate the leaks, remove the protective cover from over the diaphragm, apply soapy water to the regulator and the diaphragm, and exhale forcibly into the quick-connect opening. Air escaping through leaks will form bubbles. When soapy water is used to test other than metal parts, it should be removed carefully with clear water.

If the diaphragm leaks, remove it and clean the edge of the regulator case, including the groove; make sure that all the old cement is removed. Apply tire-tube-patching cement (the cement used with "cold patch" tire-tube repair kits) evenly but not excessively to the groove, being careful not to get cement above the groove. Install a new diaphragm evenly over the case and across the groove down to the shoulder on the case. Tightly wrap thread (the manufacturer recommends J. & P. Coats Co. white No. 8, 6 cord) four times around the diaphragm and regulator case at the groove and tie the thread securely. The diaphragm should fit smoothly with no wrinkles or folds under the thread, and the edge of the diaphragm should not extend over the edge of the shoulder on the case. Apply a protective coating of rubber cement over the thread and carefully replace the regulator cover.

Other repairs to the regulator assembly that may be safely made by other than factory personnel are the repair or replacement of the regulator shutoff- and bypass-valve assembly, replacement of the pressure-gage glass or complete pressure gage, and replacement of the female quick-connect coupling. The manufacturer recommends that the regulator assembly be returned to the factory for any other repairs or adjustments.

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Tests for Tightness of Regulator Shutoff Valve

With the regulator shutoff and bypass valves closed and the cylinder valve open, inhale from the quick-connect opening until the regulator pressure-gage pointer moves to zero. Observe the gage; if the pointer rises the regulator shutoff valve leaks. Stop the leak by cleaning the valve seat or repairing or replacing any defective parts. Do not use force to close the regulator shutoff valve to stop leakage.

Remove the regulator-valve knob and reinstall it reversed to expose the valve stem and packing-gland nut. Open the cylinder valve, then operate the regulator shutoff valve while applying a soap-and-water solution to the valve stem and packing-gland nut. The formation of bubbles indicates a leak; correct the leak by tightening the packing-gland nut or by replacing the gland packing.

Tests for Tightness of Bypass Valve

With the regulator shutoff and bypass valves closed and the cylinder valve open, place a soap bubble over the opening of the quick-connect fitting on the regulator. If the bypass valve leaks, the bubble will expand. Eliminate the leak by cleaning the valve needle or by repairing or replacing any defective parts. Force should not be used to close the valve to stop leakage.

The method of detecting and stopping leakage around the bypass-valve stem is the same as that used on the regulator shutoff valve.

Tests of Compressed-Air Cylinder

After each 5-year period the compressed-air cylinders should be returned to the manufacturer for tests; these periodic tests are mandatory to meet requirements of the ICC if the cylinders are transported on interstate carriers. The month and year of manufacture or last test is stamped on each cylinder by the manufacturer.

A leak is readily detected by immersing the fully charged cylinder in water to the valve, making sure that water does not enter the pressure-gage housing. If bubbles appear, the cylinder leaks and should be discarded.

Inspecting Assembled Apparatus

The facepiece assembly should be inspected carefully for deteriorated rubber, particularly around the lenses, exhalation valve, and inhalation tube; for cracked or broken lenses and deteriorated or broken head harness or buckles, and to determine that the inhalation tube is free from cracks and breaks and securely attached to the facepiece and quick-connect coupling with the O-ring gasket in the coupling.

The regulator should be inspected for cracks or breaks in the housing. The pressure gage should be firmly attached to the regulator with the pointer set at zero on the dial, the bypass tube should have no breaks or other openings and should be securely attached to the regulator housing, the bypass valve should be closed, the regulator shutoff valve should be open and locked in position, the regulator hose rubber should be free from deterioration or breaks with the threaded metallic ends firmly in place, and the regulator hose connections at the regulator and cylinder valve should be tight.

The wording, "To be filled with compressed air only," should be on the compressed-air cylinder. Check quantity of air in the cylinder as indicated on

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cylinder pressure gage; 1,980 p.s.i. at 70° F. indicates a fully charged cylinder; less than this amount will reduce operational time. The cylinder-valve assembly should be examined for cracks or defective parts; then the cylinder valve should be opened (turned counterclockwise three full turns) and the safety chain snapped onto the valve handwheel. See that the other end of the safety chain is attached to the base of the cylinder pressure gage. The harness should be inspected to ascertain that it is not deteriorated, that the straps are securely attached to the cylinder-holding frame, and that the harness snaps and buckles function properly.

Check the functioning of the regulator by inhaling from its quick-connect opening while the regulator shutoff and cylinder valves are open; no appreciable inhalation effort should be required to cause air to flow through the regulator.

Donning and Wearing Apparatus

To don the Scott Air-Pak, grasp the shoulder straps near the cylinder frame, raise the apparatus, and swing the shoulder straps over the head so the cylinder frame comes to rest on the back of the wearer. Next, thrust the arms, one at a time, through the loops made by the shoulder and body straps. Bending slightly forward will help to keep the apparatus in position on the back. After the apparatus is in place, fasten the shoulder straps, adjust the side straps, and fasten and adjust the waist strap. Observe the pressure indicated on the regulator pressure gage; it should be approximately the same as that indicated on the cylinder pressure gage.

The head-harness straps should be completely extended before any attempt is made to apply the facepiece. Hold the facepiece with the thumbs inside the harness and the fingers outside and then open the facepiece. Insert the chin into the lower part of the facepiece first, then pull the harness over the head, and the rest of the facepiece will slide into position. The facepiece is seated against the face by grasping the two bottom or neck straps and simultaneously pulling backward on both straps until they become snug. The two temple straps and then the forehead straps are adjusted in the same way.

The facepiece assembly is now checked for leaks and tightness of seat against the face. The facepiece should collapse without leakage when the wearer inhales with the opening of the quick-connect coupling closed. The exhalation valve is tested by exhaling while the quick-connect opening is closed; the exhaled air should pass freely through the exhalation valve.

To conserve air, the inhalation tube should not be attached to the regulator until just before the apparatus is to be used. Attach the inhalation tube to the regulator by means of the quick-connect coupling, which should be tightened firmly with the fingers. Figures 10 and 11 show front and back views of the Scott Air-Pak as worn.

When the apparatus is worn in irrespirable atmosphere, the pressure gage should be checked often enough to assure that the wearer will start out of the danger area with enough air in reserve to enable him to reach fresh air.

Maintenance and Care

Changing Cylinders

The Scott Air-Pak compressed-air cylinders can be replaced with the apparatus on a flat surface or on the back of a person; either way, the method is as follows: Close the cylinder valve, loosen the regulator-hose coupling at the cylinder valve with the wrench supplied, and uncouple manually. Raise the cam lever to loosen the

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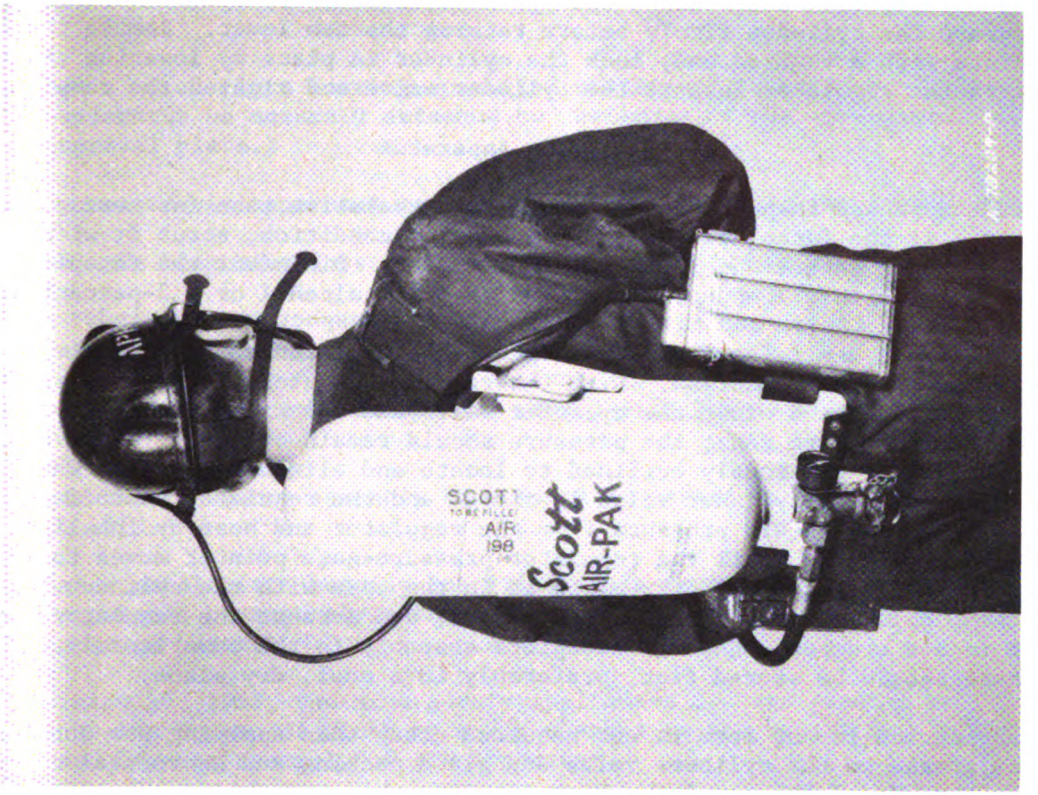

Figure 11. - Back view of Scott Air-Pak as worn.

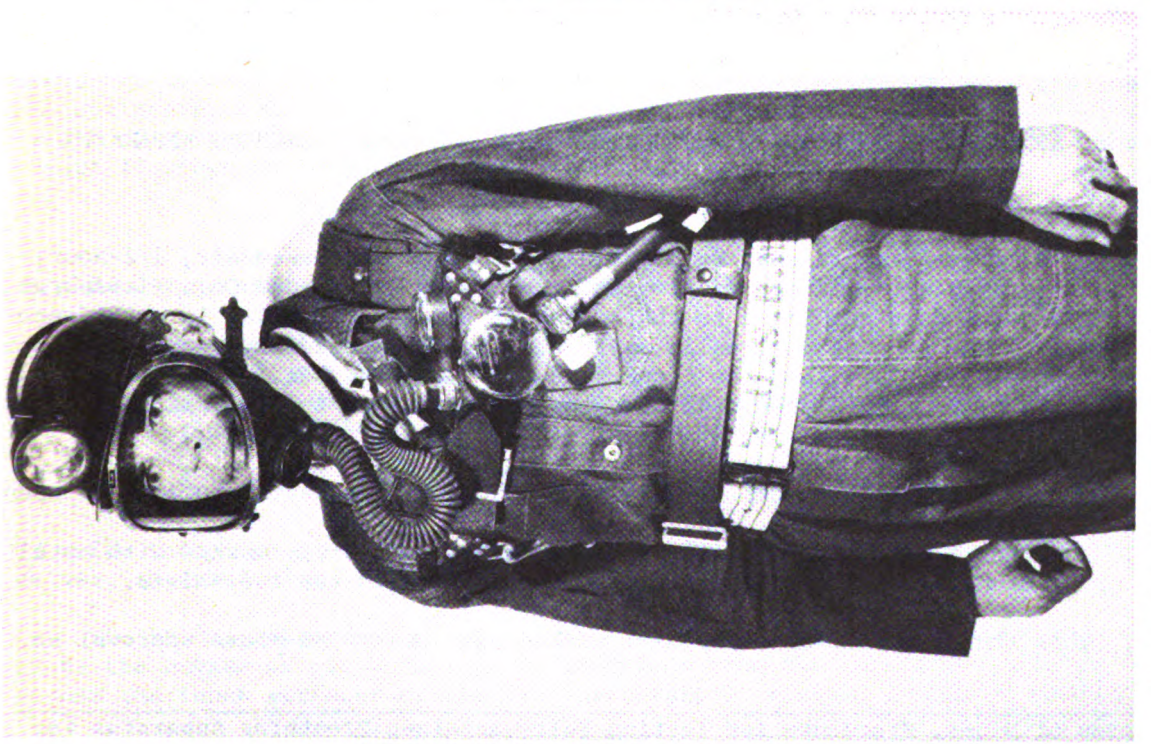

Figure 10. - Front view of Scott Air-Pak as worn (with new facepiece).

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cylinder-holding band and release the cylinder; if the apparatus is on the back of a person grasp the cylinder firmly before raising the cam lever. Remove the cylinder and replace with a charged one, lock the cylinder in place by lowering the cam lever, and attach the regulator hose to the cylinder valve and tighten the coupling.

Storing Apparatus

After each use inspect the facepiece and inhalation tube for tears, punctures, or breaks. If the facepiece assembly is in good condition, scrub it with a brush, using warm soapy water, and rinse with warm water. Disinfect the facepiece assembly by sponging it with a 70-percent solution of ethyl alcohol or a 2-percent solution of cresol compound, rinse, and air-dry. Wipe off and inspect the remainder of the equipment and correct any defects noted. Replace the depleted compressed-air cylinder with one that is fully charged. With the regulator shutoff valve open and the bypass valve closed, open and close the cylinder valve and check for leakage by observing the regulator pressure gage; the pressure should remain constant for several minutes. Follow procedures previously outlined to locate and eliminate leaks. When free from leaks, make sure the cylinder valve is closed and the regulator shutoff valve is open, and exhaust the air pressure from the regulator and hose by inhaling from the quick-connect opening until the regulator pressure-gage pointer moves to zero. After the apparatus is thoroughly dry, place it in the case with the cylinder holder on the bottom, fold the straps over the cylinder, and arrange the regulator hose so that it is not cramped. Lay the facepiece assembly in the case loosely. The apparatus case should be stored flat, preferably in a cool, dry place.

Lubrication in any form is not required other than applying Dow Corning silicone stopcock grease to the cylinder valve and gland packing and Rectorseal compound to the pipe threads of the regulator-hose fittings when assembling the parts, as recommended by the manufacturer. Care should be taken when applying Rectorseal compound to be certain that it does not enter the regulator hose and get carried to the regulator and clog the screen.

M. S. A. COMPRESSED-OXYGEN AND COMPRESSED-AIR 1/2-HOUR BREATHING APPARATUS

Approval Requirements

The M. S. A. self-contained, compressed-oxygen and compressed-air, 1/2-hour breathing apparatus are manufactured by the Mine Safety Appliances Co., Pittsburgh, Pa. The apparatus were submitted to the Bureau of Mines for testing in accordance with Schedule 13C[8/] and were formally approved, the compressed-oxygen type October 3, 1946, approval No. 1309, and the compressed-air type November 5, 1946, approval No. 1310. The compressed-oxygen apparatus was approved with the following provisions:

1. That the regulator shutoff valve be provided with a device to lock it open.

2. That the bypass and regulator shutoff valves be plainly marked with metal plates or by stamping as a means of differentiating between the two valves.

3. That the facepiece be stamped or marked with Bureau of Mines approval No. 1309.

8/ Bureau of Mines, Procedure for Testing Self-Contained Breathing Apparatus for Permissibility: Schedule 13C, July 9, 1946, 11 pp.; revised and reissued as Schedule 13D, Sept. 22, 1956, 12 pp.

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4. That the regulator assembly be stamped or marked with Bureau of Mines approval No. 1309.

5. That a metal plate bearing specified statements relative to limitations of use of the apparatus be securely attached to the frame of the apparatus. (Fig. 12 shows the approval plate.)

The compressed-air apparatus was approved with the following provisions:

1. That the breathing-tube coupling be securely attached to the regulator housing.

2. That the pressure gage be marked as an air-pressure gage.

3. That the facepiece be stamped or marked with Bureau of Mines approval No. 1310.

4. That the regulator assembly be stamped or marked with Bureau of Mines approval No. 1310.

5. That a metal plate bearing specified statements relative to limitations of use of the apparatus be securely attached to the frame of the apparatus. (Fig. 13 shows the approval plate.)

On February 25, 1955, the Mine Safety Appliances Co. was granted an extension of approval by the Bureau of Mines to cover changes in the regulator, cylinder-holding frame, and harness assembly of the apparatus.

The compressed-oxygen and compressed-air apparatus are similar in every respect, except that the oxygen and air cylinders are different in color, the high-pressure hoses are of different material and construction, and the threads of the fittings on the cylinders, regulators, and high-pressure hoses are different to prevent interchange of parts; therefore, the following descriptive matter applies to both types. Figure 14 shows the complete compressed-oxygen apparatus.

Parts of Apparatus

Each apparatus weighs about 32 pounds and has 4 main parts:

1. Facepiece assembly.
2. Regulator assembly.
3. Compressed-oxygen or compressed-air cylinder and valve assembly.
4. Cylinder-holding frame and harness assembly.

Facepiece Assembly

The facepiece assembly consists of a molded-rubber facepiece, two exhalation valves, an inhalation tube, and a rubber head harness.

The molded-rubber facepiece is the All Vision type with built-in ducts, which cause the oxygen or air entering the facepiece from the inhalation tube to flow across the inner surfaces of the two shatterproof contour lenses to prevent fogging.

The facepiece is equipped with 2 exhalation valves, 1 on each side of and on a level with the inhalation-tube connection, through which the exhaled breath is

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PERMISSIBLE
ONE-HALF HOUR
SELF-CONTAINED COMPRESSED OXYGEN
BREATHING APPARATUS
APPROVAL
NO. 1309
Issued for safety, practicability, and
efficiency in general service to the
MINE SAFETY APPLIANCES COMPANY
PITTSBURGH, PENNSYLVANIA, U. S. A.
CAUTION
1. Approved only for respiratory protection in oxygen-deficient atmospheres, or in vapors or gases which do not poison by skin absorption. (Hydrocyanic acid gas is absorbed through the skin.)
2. Approved only when the cylinder is charged with compressed oxygen and the cylinder is plainly marked, "To be filled with compressed oxygen only."
3. Approved only for use with Bureau of Mines approval No. 1309 facepiece and Bureau of Mines approval No. 1309 regulator and assembly.

Figure 12. - M. S. A. Oxygen-Demand Apparatus approval plate (No. 1309).

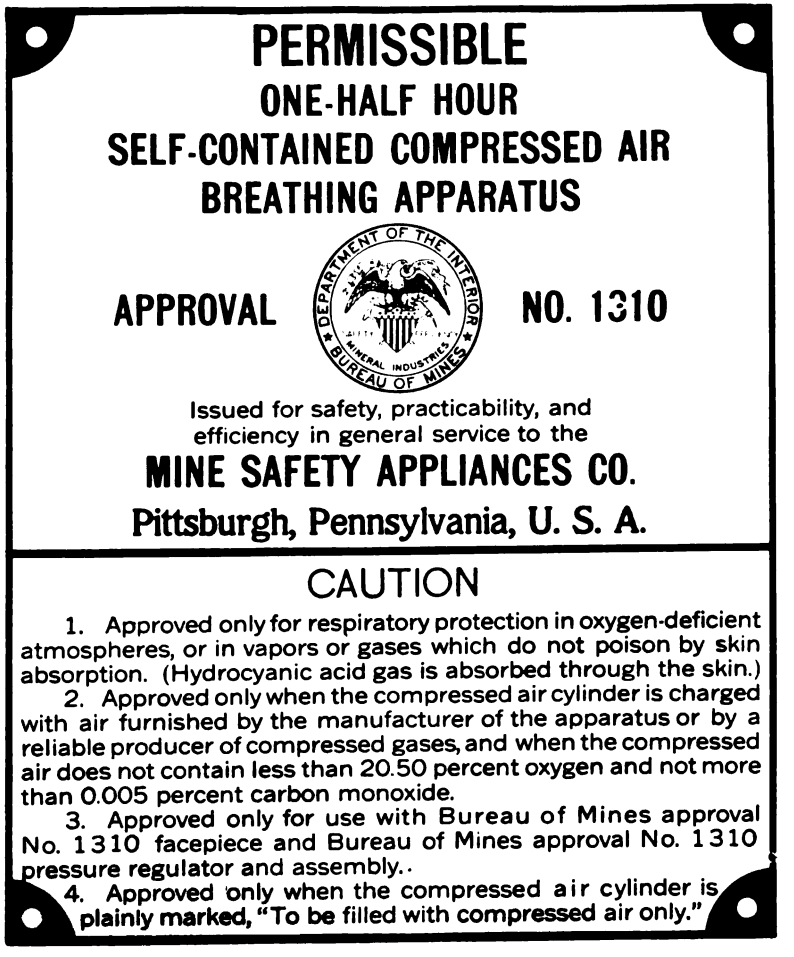
PERMISSIBLE
ONE-HALF HOUR
SELF-CONTAINED COMPRESSED AIR
BREATHING APPARATUS
APPROVAL
NO. 1310
Issued for safety, practicability, and
efficiency in general service to the
MINE SAFETY APPLIANCES CO.
Pittsburgh, Pennsylvania, U. S. A.
CAUTION
1. Approved only for respiratory protection in oxygen-deficient atmospheres, or in vapors or gases which do not poison by skin absorption. (Hydrocyanic acid gas is absorbed through the skin.)
2. Approved only when the compressed air cylinder is charged with air furnished by the manufacturer of the apparatus or by a reliable producer of compressed gases, and when the compressed air does not contain less than 20.50 percent oxygen and not more than 0.005 percent carbon monoxide.
3. Approved only for use with Bureau of Mines approval No. 1310 facepiece and Bureau of Mines approval No. 1310 pressure regulator and assembly.
4. Approved only when the compressed air cylinder is plainly marked, "To be filled with compressed air only."

Figure 13. - M. S. A. Air-Demand Apparatus approval plate (No. 1310).

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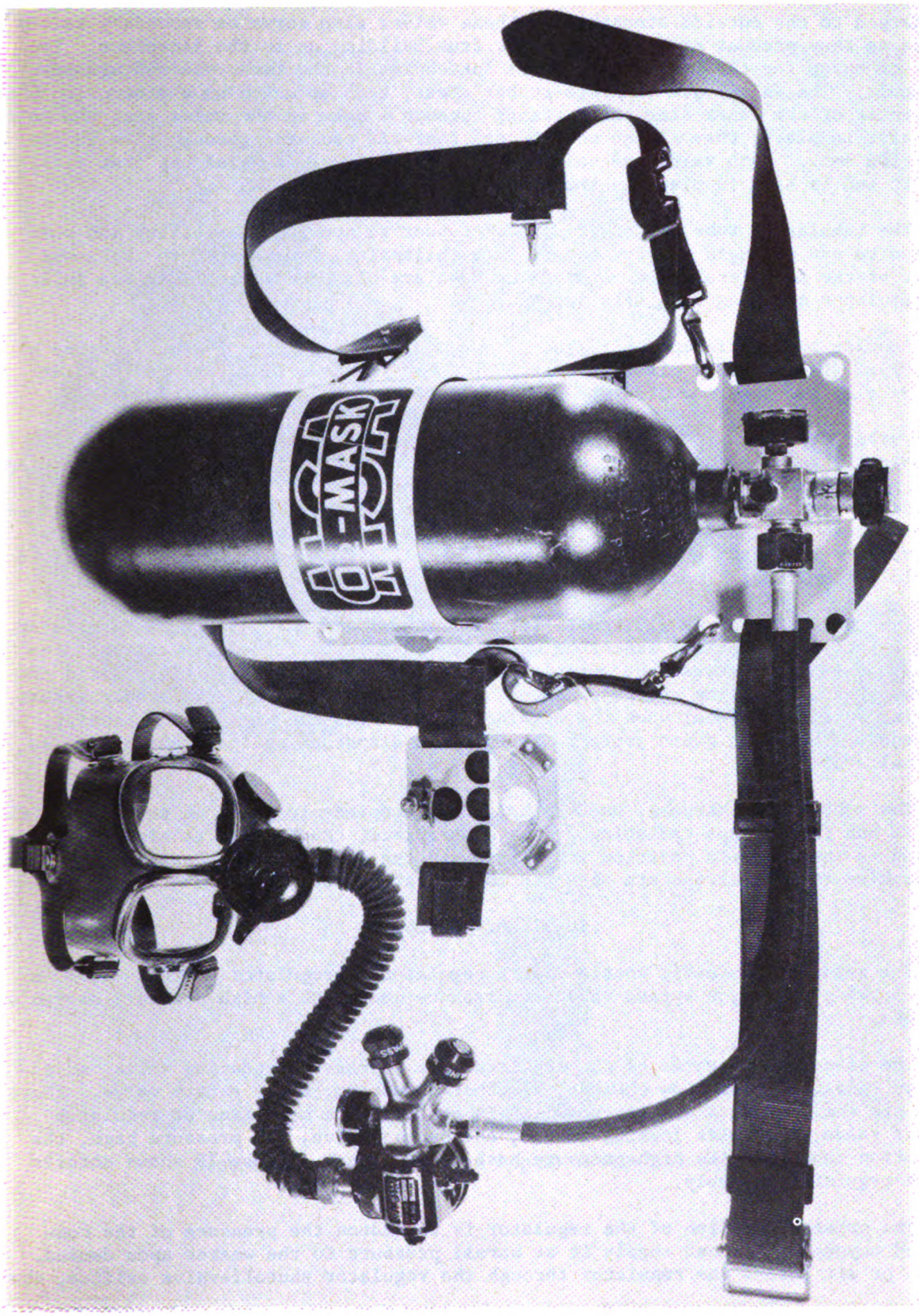

Figure 14. - M. S. A. Oxygen-Demand Apparatus layout.

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discharged to the outside atmosphere. These valves also serve as secondary safety valves as they prevent excessive pressure from building up in the facepiece. The seats or bases for the valves are fitted into holes in the facepiece and are replaceable. The valves are flexible-rubber disks, each of which has a protrusion from the center of the inner side that extends through a hole in the valve seat and holds the valve in place; they are so constructed that air can pass through them in one direction only. Each valve and valve seat is protected by a metal cap that fits over it and is held in place by the shape of the valve seat.

The inhalation tube, which is made of rubber to provide flexibility and corrugated to add strength and prevent it from collapsing, is attached to the lower center of the facepiece. The ends of the tube are clamped to the facepiece inlet and regulator coupling with metal straps.

Another type of facepiece has been approved by the Bureau of Mines for use with both types of apparatus. It is different in that it has a single rubber flutter-type exhalation valve mounted immediately above the inhalation-tube connection.

Facepieces similar in all respects to those described above, except that each is equipped with a speaking diaphragm to facilitate communication from persons wearing the apparatus, have been approved by the Bureau of Mines for use with both types of apparatus. The speaking diaphragm is attached to the front of each facepiece immediately above the inhalation-tube connection. It consists of a metal housing, a perforated-metal disk, a rubber gasket, a flexible plastic-disk diaphragm, a rigid plastic spacer ring, a metal front guard, and a metal retainer ring.

The rubber gasket is slotted to fit over the rim of the perforated-metal disk so as to provide a sealing gasket between the inner side of the disk and the diaphragm housing and between the outer side of the disk and the flexible plastic diaphragm. The spacer ring exerts pressure on the parts contacting the rubber gasket, insuring an airtight seal when the retainer ring, which screws onto the housing, is tightened. The front guard protects the plastic diaphragm against damage from an external source.

The rubber head harness, used to hold the facepiece in place on the face of the wearer, has five straps radiating from a centerpiece. Each strap is stamped near the end to indicate its position in relation to the facepiece and head of the wearer. The buckles for the straps are attached to the facepiece.

Regulator Assembly

The regulator assembly consists of a regulator, a regulator shutoff valve, a valve locking device, a bypass valve, a pressure gage, and a high-pressure oxygen or air hose.

The essential features of the regulator are a pressure-reducing valve, an admission valve, an expansion chamber, a rubber diaphragm, and a safety valve. These parts are enclosed in a housing to which is attached the main-line or regulator shutoff valve, the valve locking device, the bypass valve, the pressure gage, the inhalation tube, and the high-pressure hose connections. Figure 15 shows details of the regulator assembly.

The primary function of the regulator is to reduce the pressure of the compressed oxygen or air and supply it at normal pressure to the wearer upon demand. Oxygen or air enters the regulator through the regulator shutoff-valve orifice, then

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Figure 15. - M. S. A. Demand Apparatus regulator assembly.

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passes through the reducing-valve orifice into the reducing valve. The working parts of the reducing valve are a spring-loaded bellows and a pellet-type valve, which contacts the bellows by means of a stem. When pressure in the reducing valve is less than approximately 70 p.s.i., the bellows expands and moves the pellet-valve stem, which forces the valve pellet away from its seat and permits oxygen or air to flow from the high-pressure hose into the reducing valve. As pressure increases in the reducing valve, the bellows contracts and the valve pellet moves toward its seat until it is seated and the flow of oxygen or air into the reducing valve is cut off. It is seated when the pressure in the reducing valve reaches approximately 70 p.s.i.; thus, the pressure in the reducing valve is maintained at approximately 70 p.s.i.

From the reducing valve the oxygen or air passes through the admission valve into the second expansion chamber, thence to the facepiece and the lungs of the wearer. When the wearer inhales, a differential of pressure between the outside atmosphere and the oxygen or air in the second expansion chamber is created, and the pressure of the outside air, being greater, forces the rubber diaphragm inward. As the diaphragm moves inward, its mechanical advantage is magnified and transmitted by two levers to the admission valve, forcing it to open and to permit oxygen or air to flow from the reducing valve to the second expansion chamber. As soon as the wearer ceases to inhale, pressure in the second expansion chamber increases and moves the diaphragm outward until pressures on the outside and in the chamber are equalized and a spring forces the admission valve to close. Inhalation effort required to actuate the admission valve is equivalent to approximately 1/2-inch water-gage pressure. The cycle of oxygen or air reduction and flow is repeated as long as the apparatus is worn or until the oxygen or air in the cylinder is exhausted.

The safety valve is provided to relieve excessive pressure should the reducing-valve pellet fail to seat. When the pressure in the first expansion chamber reaches 90 p.s.i., the spring-loaded safety valve opens and permits the oxygen or air to discharge to the outside air. Oxygen or air discharging through the safety valve makes a hissing sound, which warns the wearer that the safety valve is operating.

The main-line or regulator shutoff valve, which is attached to the regulator, provides a means of shutting off the flow of oxygen or air if the reducing valve or admission valve should stick open. The regulator shutoff-valve locking device consists of notches in the edge of the regulator shutoff-valve knob and an L-shaped lever attached to the regulator with a hinge pin. The regulator shutoff valve is locked to prevent accidental closing by tipping the L-shaped lever so the end of one leg is in a notch on the regulator shutoff-valve knob.

The bypass valve is provided to furnish the wearer with oxygen or air if the regulator fails to function, and it should be kept closed unless such use is necessary. When the bypass valve is open, oxygen or air flows through a passageway directly into the second expansion chamber and then to the facepiece. An orifice in the bypass passageway restricts the flow of oxygen or air to prevent the buildup of excessive pressure in the facepiece if the bypass valve is opened too rapidly. If needed, the bypass valve should be opened first, next the regulator shutoff valve closed, and then the flow of oxygen or air through the bypass adjusted to suit the requirements of the wearer by manipulating the bypass valve. In such event the wearer should leave the danger area immediately. To aid in properly identifying the valves, the regulator shutoff valve is green and the bypass valve is red.

The pressure gage, which is attached to the regulator where it can be seen at all times by the wearer, indicates the pressure of the oxygen or air in pounds per square inch and the quantity of oxygen or air in the cylinder.

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The high-pressure oxygen or air hose from the cylinder to the regulator is a two-wire braid with synthetic tube and cover-type hose; a cylinder coupling nut is attached to the end of the hose.

Cylinder and Valve Assembly

Both the compressed-oxygen and the compressed-air cylinders are made of high-grade carbon steel, tested in accordance with ICC specifications.9/ The cylinders are 19-1/4 inches in length and 6-3/4 inches in diameter and, when fully charged to a pressure of 1,980 p.s.i. at 70° F., contain approximately 40 cubic feet of oxygen or air. The cylinder is clamped to the backplate or cylinder-holding frame with a metal band tightened with a manually operated screw device. The compressed-oxygen cylinder is painted green, and the compressed-air cylinder is yellow. Provisions of approval require the compressed-oxygen cylinder to bear the words, "To be filled with compressed oxygen only," and the compressed-air cylinder to bear the words, "To be filled with compressed air only." The compressed-air cylinder must be charged only with pure breathing air; if air compressors lubricated with oil are used as a breathing-air source, the air in the cylinder should be tested for carbon monoxide.

The cylinder-valve assembly consists of a noncorrosive-metal valve housing, a shutoff valve and knob, a locking device, an inlet stem, a pressure gage, and a safety plug. The stem of the plunger-type valve is held in the housing by a packing-gland nut and a shoulder on the valve stem. The locking device is the same in construction and operation as the regulator shutoff-valve locking device and is provided to prevent accidental closing of the cylinder valve when the apparatus is being used. The inlet stem is a perforated noncorrosive-metal tube, which extends from the valve housing into the center of the cylinder to prevent rust or sediment from entering other parts of the apparatus. The pressure gage is threaded into the valve housing and constantly indicates the pressure of the oxygen or air in the cylinder in pounds per square inch. The safety plug, which is also threaded into the valve housing, will rupture at approximately 2,200 p.s.i. It is provided to prevent rupture of the cylinder from excessive pressure that might be caused by heat or other means.

Cylinder-Holding Frame and Harness Assembly

The cylinder-holding frame or backplate is made of 1/8-inch sheet metal and is 8 inches in width and 16 inches in length. A metal band that holds the compressed-oxygen or compressed-air cylinder in place and a metal guard that protects the cylinder shutoff valve are attached to the frame. The frame has a hole near each corner for attaching the shoulder harness and slots in the bottom through which the waist strap is threaded. The harness consists of two shoulder straps, a chest strap, and a waist strap. The shoulder straps are attached to the cylinder-holding frame by means of snaps on the ends, which are snapped into holes in the upper and lower parts of the frame; the snaps on the ends of the wide straps are attached to the top of the frame. One end of the chest strap, on which is mounted a device to hold the regulator, is permanently attached to the left shoulder strap, and the other end is provided with a D-ring to which a snap fastened on the right shoulder strap is attached. The waist strap is threaded through slots in the lower part of the

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9/ Interstate Commerce Commission, Regulations for Transportation of Explosives and Other Dangerous Articles by Land and Water in Rail Freight Service and by Motor Vehicle (Highway) and Water, Including Specifications for Shipping Containers: May 1954, and Supp. No. 8, August 1956.

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cylinder-holding frame. The harness straps are made of heavy nylon webbing and are equipped with adjustable buckles and snaps so the harness can be adjusted to fit the wearer.

Flow of Oxygen or Air

Oxygen or air in the M. S. A. compressed-oxygen or compressed-air apparatus flows directly to the wearer without being recirculated or purified in the apparatus. Oxygen or air under pressure flows from the cylinder through the high-pressure hose into the regulator, where it undergoes two stages of pressure reduction, and then passes through the inhalation tube and facepiece to the lungs of the wearer. Exhaled breath passes through the exhalation valves to the outside atmosphere. Figure 16 shows details of oxygen or airflow in the M. S. A. apparatus.

Testing and Wearing Apparatus

The apparatus should be inspected and tested periodically when it is not being used and tested carefully for airtightness and working condition immediately before being worn in irrespirable or poisonous gases. All leaks found should be corrected and defective parts repaired or replaced before the apparatus is used. Only parts supplied by the manufacturer should be used as replacements. The following tests and inspections will show whether the M. S. A. compressed-oxygen or compressed-air apparatus is ready for use.

Tests for Tightness of Cylinder Valve

With the cylinder fully charged, apply a soap-and-water solution to the connection of the valve body to the cylinder, the cylinder pressure gage and its connection to the valve body, and the safety plug. Expanding bubbles indicate leaks. Leaks at connections may be eliminated by tightening the connections; however, if leaks are caused by defective parts, such parts should be repaired or replaced.

With the provided cap tightly in place on the high-pressure hose connection on the valve body and the cylinder valve open, apply soapy water around the valve stem and packing-gland nut. If bubbles appear, the packing-gland nut should be tightened or the gland packing replaced.

If bubbles appear when soapy water is applied to the high-pressure hose connection on the valve body while the high-pressure hose is disconnected from the cylinder valve and the valve is closed, the valve seat is leaking. Opening and closing the valve quickly several times may blow foreign matter from the valve and eliminate the leak. However, if the leak continues, bleed all pressure from the cylinder, and then disassemble the valve and repair or replace defective parts.

Tests for Tightness of High-Pressure Hose

With the bypass valve closed and the regulator shutoff valve open, open and close the cylinder valve and observe the regulator pressure gage. Any deflection of the pressure-gage needle indicates a leak. Leaks can be located by applying soapy water to the regulator hose and connections and to the quick-connect opening of the regulator. Tightening connections will, in most instances, eliminate leaks at these points; if a connection is defective, it should be repaired or replaced. If the high-pressure hose leaks, it should be replaced.

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LEGEND

1. High-pressure hose
2. Regulator shutoff valve
3. Reducing-valve pellet
4. Reducing-valve orifice
5. Expansion chamber
6. Spring-loaded bellows
7. Admission valve
8. Diaphragm
9. Lever
10. Lever
11. Oxygen or air passage
12. Pressure gage
13. Pressure-gage connection
14. Bypass valve
15. Bypass
16. Safety valve

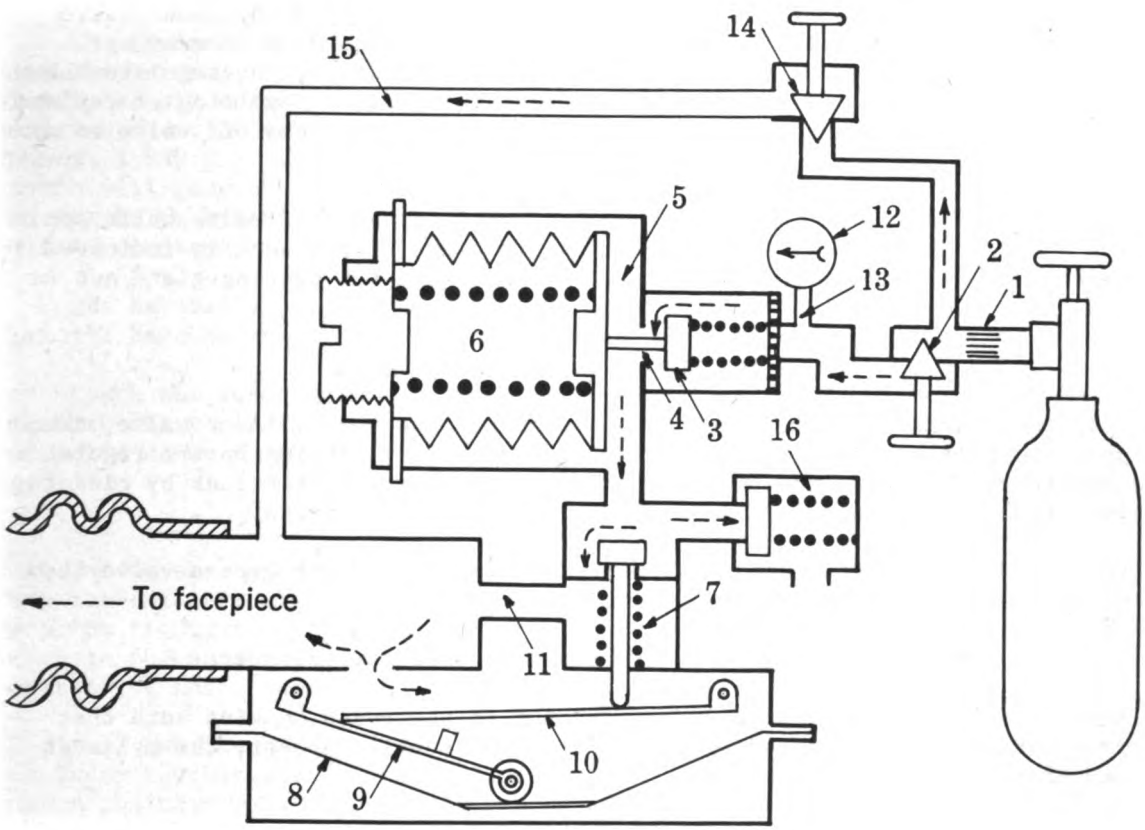

Figure 16. - Flow diagram and parts of M. S. A. Demand Apparatus.

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Tests for Tightness of Regulator

If breath can be exhaled through the quick-connect opening into the regulator while the regulator shutoff and bypass valves are closed, leaks are present. To locate the leaks, apply soapy water to the regulator and exhale forcibly into the quick-connect opening. Air escaping through leaks will form bubbles.

If the diaphragm leaks, unscrew its protective cover, which is threaded into the regulator housing, remove the defective diaphragm and replace with a new one, and then replace the protective cover. For any other repairs the manufacturer recommends that the regulator be returned to the factory.

Tests for Tightness of Regulator Shutoff Valve

With the regulator shutoff and bypass valves closed and the cylinder valve open, inhale from the quick-connect opening until the regulator pressure-gage pointer moves to zero. Observe the gage; if the pointer rises, the regulator shutoff valve leaks. Stop the leak by cleaning the valve seat or repairing or replacing any defective parts. Do not use force to close the regulator shutoff valve to stop leakage.

Open the cylinder valve; then operate the regulator shutoff valve while applying soapy water to the valve stem and packing-gland nut. If a leak is indicated by the formation of bubbles, correct the leak by tightening the packing-gland nut or by replacing the gland packing.

Tests for Tightness of Bypass Valve

Close the regulator shutoff and bypass valves; open the cylinder valve; then place a soap bubble over the opening of the quick-connect fitting on the regulator. If the bypass valve leaks, the bubble will expand. Eliminate the leak by cleaning the valve needle or by repairing or replacing any defective parts.

The method of detecting and eliminating leakage around the bypass-valve stem is the same as that used on the regulator shutoff valve.

Tests of Compressed-Oxygen or Compressed-Air Cylinders

Immerse the fully charged cylinder in water to the valve, making sure that water does not enter the pressure-gage housing. If bubbles appear, the cylinder leaks and should be discarded.

Compressed-oxygen and compressed-air cylinders should be returned to the manufacturer every 5 years for tests; these periodic tests are mandatory to meet requirements of the ICC if the cylinders are transported on interstate carriers. The month and year of manufacture or last test is stamped on the neck of each cylinder by the manufacturer.

Inspecting Assembled Apparatus

Immediately before the apparatus is worn in irrespirable atmosphere, the apparatus should be inspected thoroughly. The proper procedure of inspecting the apparatus follows:

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The facepiece assembly should be inspected carefully for deterioration, particularly around the lenses, exhalation valves, and inhalation tube; for cracked or broken lenses and deteriorated or broken head harness or buckles, and to determine that the inhalation tube is free from cracks or breaks and is securely fastened to the facepiece and quick-connect coupling and that the rubber gasket is in place in the quick-connect coupling.

The regulator should be inspected for cracks or breaks in the housing, and the protective cover over the diaphragm should be checked to see that it is tightly in place. The pressure gage should be firmly attached to the regulator with the pointer at zero on the dial, the bypass valve should be closed, the high-pressure hose should be free from cracks or breaks, the coupling nuts should be securely in place, and the hose connections at the regulator and cylinder valves should be tight.

The cylinder of the compressed-oxygen apparatus should be painted green and bear the wording, "To be filled with compressed oxygen only." The cylinder of the compressed-air apparatus should be yellow and bear the wording, "To be filled with compressed air only." Check the quantity of oxygen or air in the cylinder; in either, 1,980 p.s.i. at 70° F. indicates a fully charged cylinder; less than this amount will reduce operational time. The cylinder-valve assembly should be examined for cracks or defective parts; then the cylinder valve should be fully opened (turned counterclockwise) and locked in position.

The harness should be inspected to ascertain that it is not deteriorated and that the harness snaps and buckles are securely attached and functioning properly.

Check the functioning of the regulator by inhaling from its quick-connect opening with the regulator shutoff and cylinder valves open; the inhalation effort required to cause oxygen or air to flow through the regulator should be negligible.

Donning and Wearing Apparatus

To don the apparatus, attach the shoulder straps to the cylinder-holding frame, slip the left arm through the left shoulder strap, lay the frame on the back, then slip the right arm through the other shoulder strap. Attach the D-ring on the chest strap to the snap on the right shoulder strap and adjust the shoulder straps, if necessary. Last, fasten and adjust the waist strap.

Pull out the head-harness straps so that the ends are at the buckles, and grip the facepiece between the thumbs and fingers with the thumbs inside the facepiece. Insert the chin well into the facepiece, and pull the head-harness straps back over the head. To obtain a firm and comfortable fit against the face at all points, adjust the head harness as follows: See that the straps lie flat against the head; tighten lower (neck) straps; tighten the side straps (do not touch forehead or front strap); place both hands on the head-harness pad and push in toward the neck; again tighten the lower and side straps; and last, tighten the forehead strap a few notches if necessary.

Test the facepiece assembly for leaks and the facepiece for tightness of fit on the face by inhaling gently with the opening of the inhalation tube closed. If the facepiece collapses against the face, the facepiece assembly is free from leaks and the facepiece is seated properly. Test the exhalation valves by exhaling with the inhalation tube closed; exhaled air should pass freely through the valves.

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To conserve oxygen or air, the inhalation tube should not be attached to the regulator until just before the apparatus is to be used. Open fully (turn counterclockwise) the regulator shutoff valve and lock in position with the locking device; then attach the inhalation tube to the regulator by means of the quick-connect coupling and tighten firmly with the fingers. Figures 17 and 18 show front and back views of the M. S. A. compressed-oxygen apparatus as worn.

When the apparatus is worn in irrespirable atmosphere, the regulator pressure gage should be checked often enough to assure that the wearer will start out of the danger area with enough oxygen or air in reserve to enable him to reach fresh air.

Maintenance and Care

Changing Cylinders

The compressed-oxygen or compressed-air cylinders can be replaced with the apparatus on a flat surface or while it is being worn. In either case, the method is as follows: Close the cylinder valve; then loosen the regulator hose coupling with the wrench supplied and uncouple manually. Loosen the screw of the cylinder-holding band and remove the cylinder. Place a charged cylinder in the cylinder-holding band with the valve positioned so the regulator hose can be attached; lock the cylinder in place by tightening the cylinder-holding band screw; then connect the regulator hose to the cylinder valve and tighten the coupling by pulling firmly with an even motion of the wrench.

Storing Apparatus

After each use, inspect the facepiece and inhalation tube for tears, punctures, or breaks. If the facepiece assembly is in good condition, clean and sanitize in the same manner as described for the facepiece assembly of the Scott Air-Pak or use M. S. A. Cleaner-Sanitizer - 1 package (1 ounce) to 1 gallon of warm water. If the facepiece is equipped with a speaking diaphragm, disassemble the diaphragm and clean and dry the parts separately. Immerse facepiece assembly in the Cleaner-Sanitizer-water solution and scrub gently with a soft brush until clean, taking care to clean thoroughly the exhalation valves and all other parts that exhaled air contacts. Rinse in warm water (about 120° F.) and air-dry. Wipe off, inspect rest of equipment, and correct any defects noted. Replace the depleted compressed-oxygen or compressed-air cylinder with one that is fully charged. Check the apparatus for leaks, following the procedures previously outlined. With the cylinder valve closed and the regulator shutoff valve open, exhaust pressure from the regulator and hose by inhaling from the quick-connect opening until the pointer on the regulator pressure gage moves to zero. After the apparatus is thoroughly dry, it should be placed in its case with the high-pressure hose arranged so that it is not cramped. Place the facepiece assembly and harness loosely in the case. The apparatus should be kept in the case and stored in a cool, dry place.

Lubrication of the apparatus is not required, and all parts of the apparatus should be kept entirely free from oil and grease.

LIFELINE TELEPHONES AND FACEPIECE

The need of an efficient lifeline telephone to establish a reliable means of communication between those directing rescue and recovery operations from a fresh-air base and the leader of a mine rescue team is self-evident. Rescue teams frequently travel as far as 1,000 feet beyond the fresh-air base in irrespirable and

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Figure 17. - Front view of M. S. A. compressed-oxygen apparatus as worn.

Figure 18. - Back view of M. S. A. compressed-oxygen apparatus as worn.

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sometimes explosive atmosphere. The team members (usually 5 men) use 2-hour oxygen breathing apparatus, which formerly were equipped with mouthpieces through which the wearers breathed. The mouthpiece presented one of the problems in developing an efficient telephone, as it interfered with speech. The other major problem was providing a more efficient means of voice transmission that could not cause the ignition of explosive mixtures of methane and air.

The approval of a facepiece with a speaking diaphragm for use with the McCaa 2-hour oxygen breathing apparatus removed one obstacle, and the use of either a sound-powered or transistor-type telephone assembly, using very low wattage, appears to have overcome the second difficulty. The chief advantage of the facepiece is that it permits the team captain to transmit information clearly to the fresh-air base, but there is nothing to prevent other team members from using a similar facepiece without the telephone connection if they so desire.

Lifeline Telephone Facepiece

Experiments with the Chemox facepiece on the McCaa 2-hour oxygen breathing apparatus instead of the conventional-type mouthpiece were begun in 1953; after numerous tests and a few alterations, this facepiece was approved as supplemental mine rescue equipment in accordance with the requirements of Schedule 13D. Supplemental approval No. 1303S was issued to the manufacturer November 20, 1956.

The facepiece was approved with the following provisions:

1. That it be used only with McCaa 2-hour oxygen breathing apparatus in which the oxygen-supply tube has an inside diameter of 7/32 inch and the admission valve has 12 portholes for the passage of oxygen.

2. That the facepiece be stamped or marked with Bureau of Mines approval No. 1303S.

The facepiece assembly weighs slightly less than 3 pounds and consists of a facepiece, a head harness, a metal housing with 4 valves, and 2 breathing tubes. Figure 19 shows the facepiece with speaking diaphragm.

The facepiece is the molded-rubber "All Vision" type with built-in ducts, which cause air to flow across the inner surface of the shatterproof contour lenses to reduce fogging. In the center of the facepiece just below the lenses is a speaking diaphragm to which a lifeline telephone transmitter can be attached. The head harness consists of five rubber straps radiating from a rubber centerpiece. Each strap is marked at the end to indicate its position in relation to the facepiece and the head of the wearer; the buckles for the straps are attached to the facepiece.

A metal cylindrical housing containing two removable mica-disk check valves is attached to the lower part of the facepiece. These valves are the inhalation and exhalation valves that force the air to flow in one direction through the circulatory system of the apparatus to insure that exhaled air will not be rebreathed until it has been purified and replenished with oxygen. They can be removed from the cylinder by releasing the metal clamps that hold the breathing tubes on the cylinder, removing the tubes, and pulling the valves out; they cannot be interchanged in the cylindrical housing because the housing of each is different in construction.

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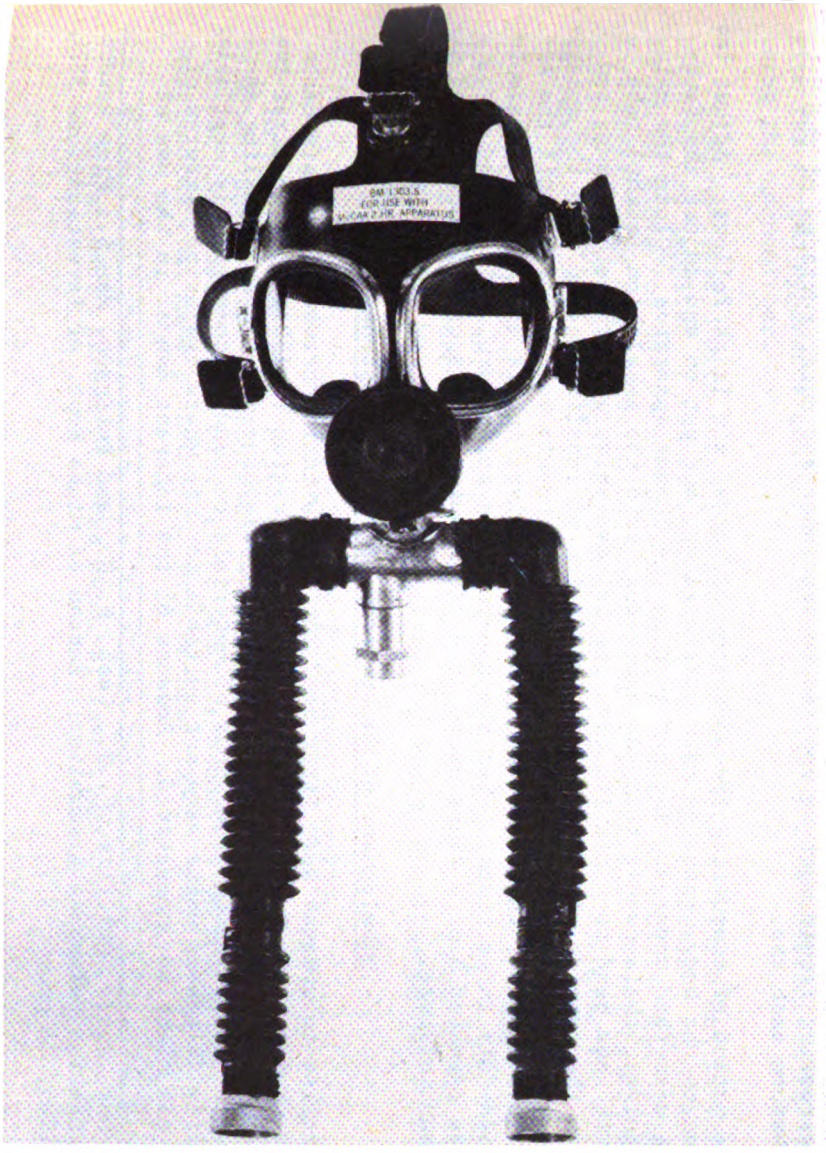

Figure 19. - Facepiece with speaking diaphragm for use with McCaa 2-hour oxygen breathing apparatus.

Figure 20. - Facepiece with lifeline telephone transmitter as worn with McCaa 2-hour oxygen breathing apparatus.

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Attached to the lower side of the metal valve housing, in which the inhalation and exhalation valves are mounted, is a cylindrical housing that contains a hand-operated plunger-type valve and a fixed mica-disk check valve. With the hand-operated valve, nitrogen can be released, excessive pressure lowered, and liquid expelled from the apparatus. The fixed mica-disk valve prevents outside air from entering the circulatory system of the apparatus when the pressure-release valve is open. All the valves, except the hand-operated valve, are activated by pressure from inhaling or exhaling. Coil springs keep the fixed mica-disk and hand-operated valves closed when they are not being used.

The breathing tubes, which are attached to the ends of the metal cylinder by clamp-type metal straps, are made of rubber to provide flexibility and are corrugated to add strength and prevent collapse. The breathing tubes of the facepiece assembly, as used with the Chemox breathing apparatus, were not long enough when used with the McCaa apparatus to allow the wearer enough freedom of head movement; therefore, a 3-inch extension was added to each tube. The extensions are corrugated rubber and are attached to the tubes by means of short metal tubes and clamp-type metal straps. Threaded metal couplings are attached to the breathing-tube extensions with metal clamp-type straps. The tube to the right of the wearer is the exhalation tube, and it couples to the noncollapsible tube connected to the regenerator of the apparatus; the tube to the left of the wearer is the inhalation tube, and it couples to the noncollapsible tube connected to the cooler of the apparatus. Rubber gaskets in the threaded metal couplings permit airtight connections to be made by tightening the couplings with the fingers and a wrench. Figure 20 shows the facepiece with lifeline telephone transmitter, as worn with McCaa 2-hour oxygen breathing apparatus.

Procedures for inspecting, testing, wearing, and maintaining this facepiece assembly are the same as those described for the Chemox facepiece assembly, except that fogproofing liquid must be applied to the inner and outer surfaces of the lenses before each use.

The method of evacuating the apparatus of normal air is as follows: Adjust the apparatus to the body, open the main bottle valve, and put on and adjust the facepiece as described under donning and testing the Chemox apparatus. Close the main bottle valve, inhale deeply from the apparatus, grip the exhalation (right) tube firmly with one hand to close it, open the release valve with the other hand, and exhale to the outside air. Repeat the operation of inhaling deeply from the apparatus and exhaling to the outside air with the main bottle valve closed until the apparatus is evacuated; then open the main bottle valve, inhale deeply, and exhale to the outside air three times. When the apparatus is being worn, this procedure should be repeated 3 or 4 times every 15 or 20 minutes to dispose of accumulated nitrogen and moisture.

Development of Batteryless Lifeline Telephones

Lifeline telephones were first used for communication between fresh-air bases and mine rescue crews in the Lake Superior mining region in 1921.[10/] The first two units, which were battery-powered, combination telephone-and-buzzer signaling devices, were made in local mine shops of materials on hand or commercially available. These early telephone units were not suitable for use where explosive mixtures of air and gas might be encountered. Because of the inherent danger in the use of

10/ Forbes, J. J., Griffith, F. E., Cash, F. E., and Petersen, Max S., Mine Rescue Lifeline Telephone Assemblies: Bureau of Mines Rept. of Investigations 3875, 1946, 11 pp.

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battery-powered telephonic equipment in explosive atmospheres and because of the difficulty and confusion experienced by mine rescue crews when attempting to give signals by means of a sashcord-type lifeline, the Bureau of Mines began an investigation in 1937 to develop batteryless telephone equipment that could be used safely in irrespirable atmosphere. The chief problem in developing this equipment was the design of a suitable combination voice- and body-vibration-powered transmitter that would be practicable under actual working conditions.

Following experiments with commercially available dynamic and crystal-type microphones and transmitters, modifications were made to one dynamic-type transmitter by adding a second diaphragm and by making other slight changes. The performance of the modified transmitter was satisfactory when used as a throat transmitter without the use of batteries. This development permitted the assembly of a mine rescue telephone that would operate efficiently without the use of batteries. The assembly consisted of 1,200 feet of 2-conductor cord, 2 dynamic-type receivers, 1 vibration-powered transmitter, 1 voice-powered transmitter, and 1 suitable cord reel. The total weight of the complete assembly was about 175 pounds.

After extensive field tests of the telephone assembly, it was decided that modification of the mouthpiece used in connection with oxygen breathing apparatus was desirable.

A mouthpiece was developed that consisted of a half facepiece and rubber mouthpiece combined to permit relatively free movement of the lips and provide a tight seal around the nose and mouth. The assembly has been used several thousand manhours over a period of several years without major changes. While excellent performance was obtained from the equipment, it was recognized that further refinements could be made to improve the overall efficiency. These would include a reduction in weight of the equipment and development of a means whereby the mouthpiece required with the oxygen apparatus could be eliminated to give free movement of the lips when using the transmitter.

A sound-powered wire communication system has been developed and is being marketed by one supplier of safety equipment. The equipment has been approved by the Bureau of Mines for use with Chemox and demand apparatus, canister gas masks, and hose masks. The communication equipment worn by the captain of rescue teams consists of a facepiece equipped with a speaking diaphragm and headgear for supporting earphones.

The telephone equipment is connected to a small 2-conductor cable, 125 feet or more in length. A reel is provided to accommodate the connecting cable. The telephone used at the fresh-air base is of the handset type, connected to the circuit by a detachable plug. The assembly, being sound-powered, requires no batteries or external power.

Battery-Powered Transistor Telephone

In 1954 the Bureau of Mines developed a low-voltage battery-powered lifeline telephone unit, which incorporated several modern electronic developments.[12/] This unit was first used during mine rescue practice maneuvers in the Bureau of Mines Experimental coal mine at Bruceton, Pa., October 1954.

12/ Brown, C. L., Development of a Transistor-Type Telephone System for Mine Rescue Operations: Bureau of Mines Rept. of Investigations 5318, 1957, 11 pp.

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The battery-powered lifeline telephone has several advantages over the sound-powered type, such as: Less weight, smaller cord and reel, more distinct sound reception, and means by which the wearer can control the volume of incoming sound.

Although batteries are used as a source of power in this telephone assembly, the voltage and current are low, and exhaustive tests by the Bureau of Mines have proved that it can be used safely in atmospheres containing explosive gas-and-air mixtures.

Parts Used in Assembly

At present (November 1956) the battery-powered lifeline telephone is not commercially available; however, most of the parts in the assembly developed by the Bureau of Mines are commercially available.

The battery-powered lifeline-telephone assembly consists of 2 transmitters, 2 receivers, 2 transistor amplifier units powered with miniature dry-cell batteries, 2 small cloth bags with straps, a 1,000-foot lightweight 2-conductor cord, a reel to hold the cord, a 30-foot cable, 3 plug-in-type connectors, and 1 portable cable connector. Figure 21 shows the complete layout of the battery-powered telephone, with names of the principal parts.

The transmitters are hearing-aid microphones adapted for use in the assembly. The microphone used at the fresh-air base is mounted in plastic for protection and ease of handling. Two types of transmitters were made for use by a mine rescue team member; one has the hearing-aid microphone mounted in plastic and is equipped with an elastic strap so it can be used as a throat-type microphone, and the other is a similar microphone mounted in a plastic holder attached to the speaking-diaphragm housing of a facepiece. Each of the latter two transmitters has an off-and-on switch. The receivers are hearing-aid earphones that fit into the ear.

The amplifier units are transistorized hearing-aid amplifiers, mounted in 1-1/8- by 2-5/8- by 3-1/4-inch plastic cases. Each amplifier is powered with a 2.4-volt, 2-cell transistor battery and is equipped with a volume control and an off-and-on switch. The volume control permits the wearer to regulate the volume of incoming sound, and the off-and-on switch is provided to cut off the power to conserve the batteries. The amplifiers are carried in small cloth bags equipped with straps, which pass around the neck and waist of the person using the unit.

The 1,000-foot, 2-conductor cord (signal-corps wire) is used instead of a conventional lifeline and also serves as the telephone line. One end of the cord is attached to contactors on the reel; the contactors are connected to a female receptacle on the frame of the reel, and the other end of the signal-corps wire is equipped with a female receptacle. The reel serves as a storage place for the cord and is provided with a crank so the cord can be retrieved; however, the signal-corps wire is considered expendable and need not be retrieved. The reel is carried by a member of the rescue team; the 30-foot cable, which is 5/16-inch-diameter, 2-conductor, rubber-insulated electric cord, is used as a telephone extension from the reel to the amplifier unit worn by a team member, generally the captain; it also serves as a hand cable for the team members. Harness snaps near each end of the 30-foot hand cable permit the ends of the cable to be secured to the frame of the cable reel and the belt of the team member wearing the telephone unit, thereby eliminating strain on the plug-in-type connectors and reducing the possibility of the connections being broken inadvertently.

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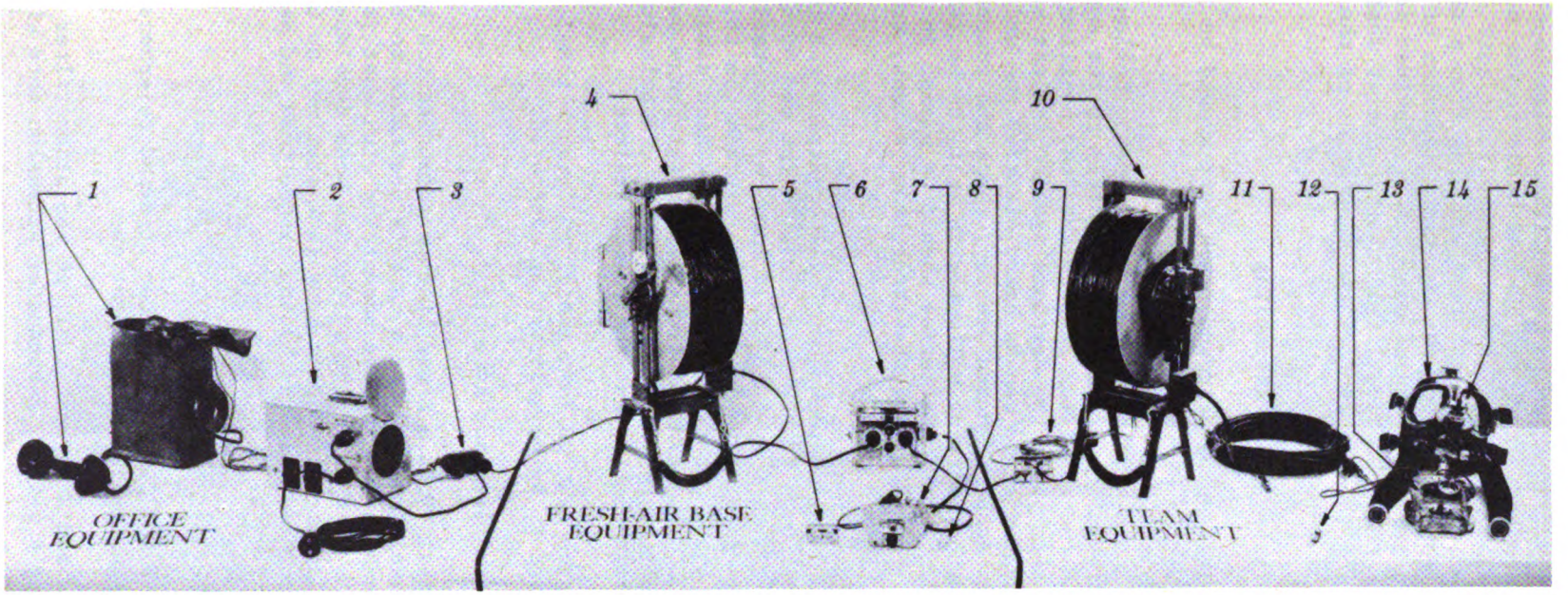

1. Signal Corps hand-phone
2. Loudspeaker amplifer
3. Three-way junction connector
4. 1,000-foot pay-out cable reel
5. Microphone
6. Isolation and filter pack
7. Sound amplifier
8. Earphone
9. Phone portable cable connector
10. 1,000-foot pay-out cable reel
11. Rescue team section of life-line
12. Earphone
13. Sound amplifier
14. McCaa 2-hour apparatus facepiece
15. Facepiece microphone

Figure 21. - Battery-powered lifeline telephone layout.

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The plug-in-type connectors are used to connect the amplifier units to the lifeline cord and the 30-foot cable and to connect the 30-foot cable to the cord reel. A plug-in-type connection is also provided between the amplifier unit and the microphone used by the rescue-team member to facilitate changing from a throat-type microphone to a tranmitter that is attached to the speaking diaphragm of a facepiece, or vice versa. A portable telephone-cable connector is provided so that the telephone unit may be attached to the telephone lifeline at any point desired by means of screw clamps, the points of which penetrate the insulation of the lifeline cord.

Inspecting, Testing, and Assembling

Before the telephone equipment is used underground, each part should be inspected thoroughly and tested to insure proper functioning.

Each telephone-amplifier unit should be checked separately by the following method: See that the earphone and microphone are attached securely to the amplifier unit, push the sliding switch on the amplifier unit to the "on" position, turn the volume control knob to half on, then place the earphone against the ear and tap lightly on the microphone; if the tapping sound can be heard clearly, the unit is ready for use. If the tapping sound cannot be heard clearly, check the connections and the transistor battery. Use a direct-current voltmeter to test the battery; new batteries should give a reading of 2.4 volts. Batteries should be placed in the amplifier unit with the positive side, the side that has three indentations, toward the outside of the unit.

To assemble the battery-powered lifeline telephone for use, attach the telephone unit to be used at the fresh-air base to the receptacle on the end of the cord on the reel. Plug the connector on the 30-foot hand cable into the receptacle on the reel frame and attach the harness snap to the reel frame. Attach the telephone unit to be used by the rescue team to the other end of the 30-foot hand cable and attach the harness snap to the belt of the team member using the telephone unit. After the assembly has been completed, check the system for voice transmission and, if necessary, adjust controls to obtain clarity and the volume desired.

The reel is usually carried by the next to last man of the rescue team, who is assisted by the last man when the wire is being paid out or retrieved.

Three-Point Telephone Assembly

The preceding description has dealt with a 2-way line of communication between the rescue team and the fresh-air base; however, it is usually desirable to have those in charge of recovery operations on the surface acquainted with what is transpiring underground, and to meet this need a 3-point system has been developed for use with the transistor-operated telephone. A public-address system may be used to amplify the sound of voices from the telephone used by the rescue team and persons directing the work from the fresh-air base.

The three vital communication points are illustrated in figure 22.

In addition to the parts used in the 2-way transistor lifeline telephone, the following parts are required to provide 3-point communication:

Two-conductor signal-corps wire and a pay-out reel, an isolation filter pack, an Army signal-corps field telephone, a 4-foot, 2-conductor extension cord with 1

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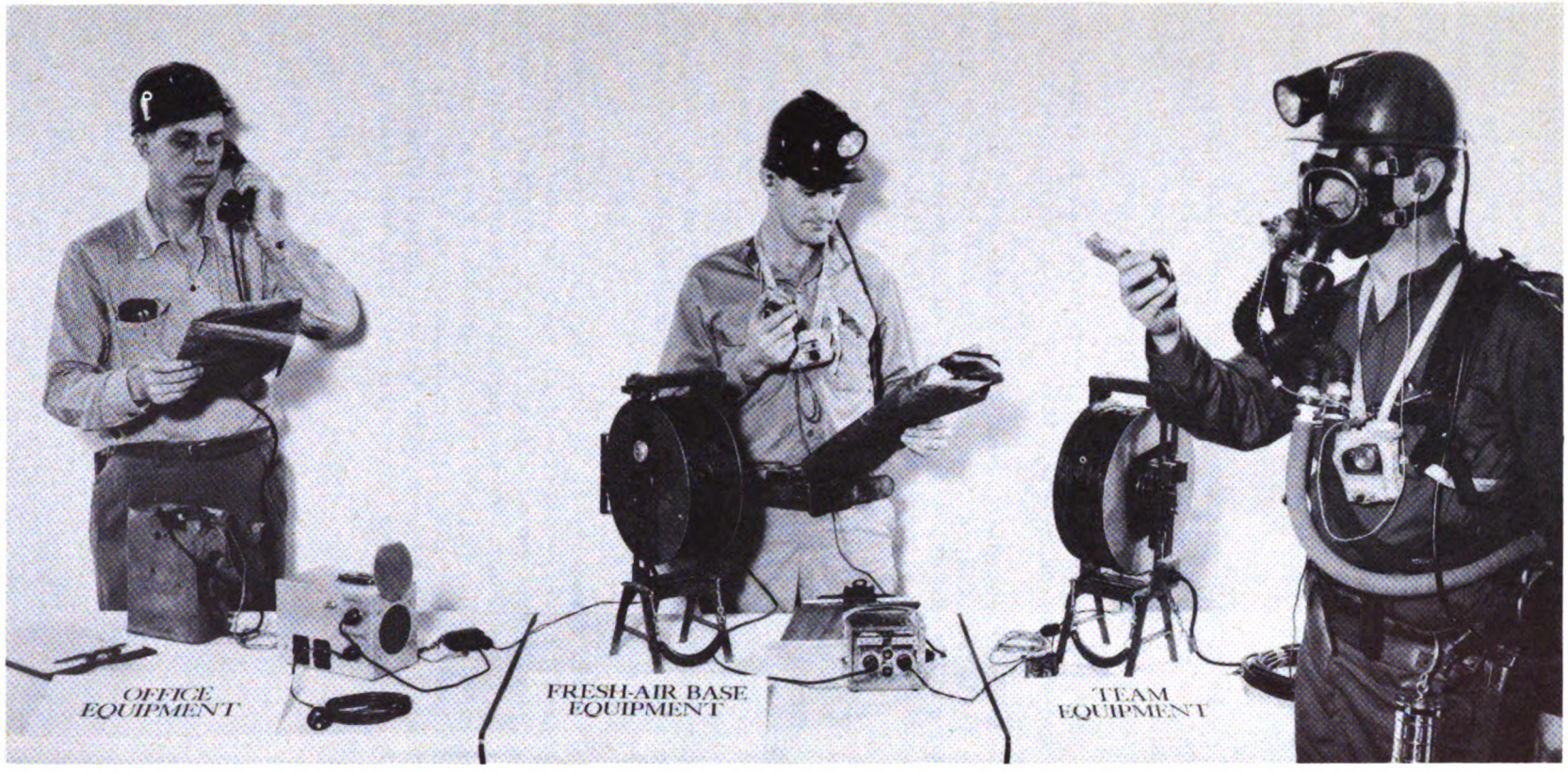

Figure 22. - Lifeline telephone as used.

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male and 1 female receptacle, and a 4-foot, 2-conductor extension cord with 1 male receptacle and 2 plug-in connectors. If the third point is to be connected with a public-address system, a 3-way connector with 1 male and 2 female receptacles, and 1 microphone, 1 amplifier, and 1 loud speaker also are required.

A second reel of 2-conductor signal-corps wire is provided to serve as the telephone line from the main base of operations to the fresh-air base. Additional signal-corps wire may be used as needed, or part of the mine-telephone circuit may be reestablished and used to reach from the surface or main base of operations to the fresh-air base.

A female receptacle is attached to one end of the signal-corps wire, and the other end is attached to contactors on the payout reel, which in turn are connected to a female receptacle on the frame of the reel. The payout reel serves as a storage place for the signal-corps wire and facilitates stringing it.

The isolation filter pack prevents extraneous voltages from passing to the low-voltage transistor two-way telephone circuit.

The 4-foot, 2-conductor extension cord with 1 male and 1 female receptacle is used to connect the isolation filter pack to the reel of the 2-way telephone system; and the 4-foot, 2-conductor extension cord with 1 male receptacle and 2 plug-in connectors is used to connect the signal-corps wire to the field telephone.

To assemble the three-point system, connect the receptacle on the end of the signal-corps wire to the field telephone and/or the public-address system; then unreel and string the signal-corps wire from this location to the fresh-air base, splicing in additional wire as needed. Plug the receptacle on the end of the lifeline telephone cord into the receptacle (marked reel No. 1) on the isolation filter pack, plug the fresh-air telephone unit receptacle into the side of the isolation filter pack, and then plug one end of the 4-foot extension cord into the receptacle on the frame of the reel and the other end into the receptacle (marked reel No. 2) on the isolation filter pack.

This latest telephone assembly, including the public-address equipment, has been tested under actual recovery operations after a disaster resulting from an explosion and fire. The telephones were used in this operation in the manner previously described and, in addition, by semipermanent circuits established as recovery operations progressed. These circuits were extended several miles throughout the mine, and the performance of the telephones was good during the time of severe duty. Additional field tests were made with the assembly during the recovery operations in opening an area of another coal mine that had been sealed as the result of a fire.

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